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## URBANIZING RURAL LIFE[1]

The talent, the energy, and the revenue of the Government have been devoted during the quarter of a century of American Occupation of the Philippines mainly to the improvement of conditions in cities and sub-cities. So we find in cities and sub-cities better living, educational, and recreational facilities, better houses, better water systems, better transportation, better markets, better health service, better mail, telephone, and telegraph service, better schools than in the rural districts. There are also found in cities and sub-cities theaters and other amusements which are usually lacking in the rural districts. Industrial, manufacturing, and commercial establishments so abound in cities, that it is not difficult for one to find work and live there. People find more contentment in city life; it is more sure and more satisfying.

On the other hand, we find conditions in the rural districts very unsatisfying. Generally there is no church. The roads and streets are ill-kept. Schools, if there are any, are not so well equipped and not so well taught as those in the cities. There are no physicians, no dentists. There are no theaters; amusements of any nature are rare. The work on the farm is hard. The wages are low. Many people who have nothing to hold them in the rural districts, sooner or later realize that it does not pay to live there. They move city-ward. They crave city conveniences and enjoyment. They are entitled to them, and they go where they can find them.

A result of this city-ward movement of the rural population is congestion of population in cities and sub-cities. We find today Manila, Iloilo, Cebu and other large cities in the Philippines with congested districts, owing to the rapid influx from the country, while the rural population is thinning out. The signs are that this depletion will continue. The lawyers, the physicians, the dentists, the engineers, the clergymen, and people of other professions and occupations huddle themselves in cities. It does not pay them to live in the rural districts, for the residents there cannot pay enough for their services. Well-to-do farmers also move to the city for the sake of city conveniences. The movement of farm workers toward the city results in a decreasing number of people, proportionally, producing food stuffs and raw materials for industry and manufacture. This spells high cost of living, and puts industry and manufacture in an unstable condition. The movement of well-to-do farmers to the city results in absentee landlordism, and lowers the educational level of the rural people.

Shall we continue improving our cities and sub-cities with little regard for the improvement of the conditions in the rural districts, or shall we build cities

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and sub-cities backed by productive rural districts populated by an intelligent, prosperous, and contented rural people? The present tendency of the social order is not conducive to rural amelioration; it portends gloom for the economic condition of the country in the future. There are forces that can be set in motion by which the conditions in the rural districts may be improved. The rural districts should be urbanized. Unless these districts are furnished with better living, educational, and recreational facilities and better business facilities, the rural population will become unstable.

Better rural roads, better mail, telephone, and telegraph service, the radio and the automobile would make rural life less isolated. A more effective extension of the health and public welfare service would be a blessing to the rural people. Extension of the educational service of the Government both to the young and to the old would be of incalculable value. A powerful agency for rural good is an effective agricultural extension service. There is no public institution, no private agency, and no profession that can not make contribution to rural improvement. The rural districts are very fertile fields for church activities. The rural people are religiously and morally plastic. Is it not to be regretted that the ministers of all denominations practically confine their soul-saving work to the cities? And so do the social reformers.

Each rural district urgently needs a civic center. A decent schoolhouse, an attractive sub-municipal building, a modest church, and a public playground are indispensable to intellectual growth, religious functions, and recreational activities.

Improvement of rural conditions can come from within and from without. Local talent has a great potentiality. Properly guided, much physical improvement can be accomplished by the rural people. The ownership of a playground and a park, and the construction of public buildings for educational, civic, and religious use can be accomplished by the rural people with a little help and direction from the Government.

Politics and bureaucracy have done much to curtail and spoil the initiative of the rural people. Less interference and more frank talk from Government officials as to what help the rural people can expect and as to what they cannot expect from the Government will create more public consciousness among those who live in the country.

The use of rural talent in songs, dances, and dramatic art in public entertainments will greatly encourage the farming population to participate in public affairs. Nothing is more destructive to the initiative of people who live in the country than to make them feel that they are rustic and that their manners and methods are out of date.

At no time in the history of the country is unselfish rural leadership more needed than at this time. Industry, manufacture, and commerce are attracting a large number of farmers. The problem of making these people remain in the rural districts is becoming increasingly difficult. Young men who leave the rural districts to secure an education do not return. How can the rural people be made to remain in the rural districts? How can these districts be populated with more intelligent people?

"Better farming, better farm living and better farm business" is an accepted formula to cure rural ills. The rural problem is economic and social. If we

would make the living conditions in the rural districts satisfactory there would be no shortage of rural population. If we would make farming pay, there would be no shortage of farmers.

The earning power of the rural people is a great factor in rural improvement. Their paying power depends upon their earning capacity. The amount and quality of what they can buy in the form of enjoyment, physical improvement, health service and what not depends on their paying power. The urbanization of the rural districts depends much on the paying power of the rural people. Therefore, any movement or legislation that will tend to increase this power will be conducive to rural improvement.

Rural prosperity is necessary to national prosperity, especially in an agricultural country like the Philippines. History shows that the decadence of ancient cities can be traced to rural unmindedness and neglect. If modern cities are thriving, it is because there are productive rural districts behind them.

Many city industries are dependent for raw materials upon the rural districts. So is commerce which deal in products raised on the farms. To keep the wheels of industry, manufacture, commerce, and transportation turning, the farms in the rural districts must be kept permanently sustaining. Any factor disturbing the productivity of the rural districts, as the city-ward movement of population, will affect unfavorably the economic stability of the country. A good proportion of the country's population should be kept in the rural districts. This can be done only by urbanizing these districts, improving the living conditions of the rural people, educating them in better methods of farming that they may be able to increase their efficiency, and extending to them better business facilities that they may be able to increase their paying power for those facilities and conveniences that make rural life less isolated and more satisfying.

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# A STUDY OF SEX CHANGE IN PAPAYA AND OF CORRELATION BETWEEN SEX AND CERTAIN MORPHOLOGICAL CHARACTERS OF SEEDLINGS[1]

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WITH THREE PLATES

## INTRODUCTION

Determining the sex of seedlings of papaya (*Carica papaya* L.) from their external characters or appearance has long been a moot question among horticulturists and botanists and a matter of interesting speculation among papaya planters in the tropics. Though normally dioecious, with male and female flowers produced on separate trees, the papaya is widely variable as to sexual expression, as many as thirteen sex forms being described by Higgins and Holt (1914)[2]. Of these forms the most important—being the ones most commonly met with in the orchard—are the male and female of the dioecious type, and the hermaphroditic forms, elongata and pentandria. In any lot of seedlings, until flowering time, it can not be told which individuals are to be one or other of the various sexual types, for while the papaya is dimorphic (if not really polymorphic) as to sex characters it is not, so far as known, dimorphic vegetatively. That is, no external vegetative character has been found, as yet, to be associated with sex; secondary sexual characters in papaya are unknown. This condition is obviously a hindering feature in the papaya industry. When it is remembered that pistillate trees of the dioecious type are sometimes used as sources of seed; that a fairly large portion of the seedlings from a given lot of seed from such trees often turn out to be staminate, frequently reaching as high as 75 to 85 per cent (Higgins and Holt); and that, generally, a comparatively few male trees are sufficient to supply the pollen to fertilize the female flowers, the importance of studying the external morphology of the seedlings for the purpose of discovering any possible correlation or association between sex and certain seedling characters, which amounts to the same thing as the isolation of some secondary sexual character or characters, is very evident.

Secondary sexual, or sex-limited character is defined by Babcock and Clausen (1918) "as a character not immediately concerned with reproduction, but found only in one sex," and by it alone the sex of the individual is easily recognized. If any such character be present in the papaya seedling, its isolation will at once enable the grower to eliminate such portion of the male seedlings as he does not need in his orchard and thus prevent much loss of time and expense. There is one natural obstacle in this study for such character; namely, that except as to their flowers the adult plants of the different sexes are not distinguishable

[1] Thesis presented in 1925 for the degree of Master of Science in Agronomy from the University of the Philippines, No. 211; Experiment Station contribution No. 323.

[2] There is a type of female papaya not described by Higgins and Holt. It is one in which the flowers are borne on long pendent peduncles, very similar to those of the male tree. This has been noted also by Kulkarni (1915).

to any conspicuous degree. Can the female, male, and hermaphrodite seedlings be any different vegetatively?

*Current beliefs among Filipino farmers relating to alleged correlation between sex and certain seedling characters*

In the towns of Bay, Calauang, and Los Baños, of the province of Laguna, where the papaya is cultivated quite extensively for local export, a good many farmers have interesting and rather peculiar beliefs and practices which bear on the subject under review. These farmers claim that they can tell the sex of the papaya seedling from the character of its root system and foliage, and can establish an orchard consisting very largely, if not wholly, of fruit-bearing forms. As no research has been conducted on this problem, so far as the writer can ascertain, these claims are little more than speculations. Some of the beliefs even border on superstition. A few of these practices will be considered here briefly.

One of the fairly widespread beliefs is that relating to an alleged difference in the root system of the male-to-be and female-to-be seedlings. It is claimed that seedlings which have the taproot with its branches as the only primary root system are male, and those which leave no primary root system but have main roots of about equal size are female. There are some farmers who accept the reverse of this belief. The removal or cutting back of the taproot of the supposed male seedlings at transplanting time will cause them to turn out pistillate. These farmers do not distinguish the female from the hermaphrodite trees.

It is believed by some that seeds having the pistillate tendency are found at the upper half, or stem section of the fruit while those of the staminate tendency are at the lower, or apical region.

A few maintain that staminate seedlings are characterized by the first leaf being lobed, whereas in pistillate and hermaphrodite seedlings this leaf is entire. The succeeding leaves are the same in all the seedlings, it is said.

Still another belief, though less common than these, is that "slender seedlings are destined to be male, whereas the more robust ones are to be female."

*Sex change in papaya*

It seems to be a widespread belief in sections of the tropics where the papaya is cultivated, that the sex of the so-called male plant can be changed by the simple process of topping, or removing the terminal bud. Authentic cases of sex change in the papaya, from the non-fruiting male to the fruit-bearing female or hermaphrodite or both, have been reported by investigators in Hawaii, India, Porto Rico, and elsewhere. The female papaya has not yet been found to alter its sex (Higgins and Holt, 1914). Such an unusual behavior of sex in the male was considered incredible by Coulter and Coulter (1918). In M. C. Coulter's (1923) *Outline of Genetics*—a revised edition of *Plant Genetics*—a change of viewpoint is apparent as expressed in the following statement:

> At the present date there is probably more evidence to support physiological theories of sex determination in plants. . . . Botanists usually feel that the potentialities for both sexes are at all times present in all the tissues of the individual, and that it remains for some unknown complex of physiological condition to call one or the other sex in any given region of the plant.

That one sexual state could be so completely and easily transferred into another would indeed appear incredible to most of those who believe strictly in

the chromosome theory that sex is absolutely determined by the kind of gametes which unite to form the zygote at fertilization, and that no outside conditions can alter the sexual state after the sexual fusion. According to this theory sex is inherited in the ordinary Mendelian fashion, with either the male or female as heterozygous for simple sex determiners and with males and females in about equal ratio as the only possibilities. Whether this sex mechanism holds true with papaya, is not known. But the chromosome mechanism of sex determination has been directly or indirectly found to be operative in such dioecious seed plants as *Bryonia* by Correns (1913); in *Melandrium* by Strasburger (1900); in *Lychnis* by Shull (1910); in *Elodea* by Santos (1924) and Strasburger (1900); and in a few others. Opposed to this strict hypothesis of sex for plants are some botanists, as Schaffner (1921, 1923), who contend that sex determination and sex reversal in seed plants lie outside the activities of chromosomes, and are matters closely related to the purely physiological activities of the organism in response to its environment.

This reported behavior of sex change in papaya opened up a possible means of converting the superfluous male plants in an orchard to fruit-bearing individuals. The treatments used by various investigators to effect the change did not, however, always bring about the desired results, the positive cases being few and far between. It is not even definitely known just what factors or set of conditions were directly responsible for the observed changes, though theories have been put forward to account for the results. If it could be proved that, done under Philippine conditions, topping or some other operation will cause sex reversal with certainty, it would be of real practical value; especially if no vegetative part or character of the seedling were found to be correlated with its future sex.

*Review of literature on sex change in papaya*

Iorns (1908), who conducted in Porto Rico experiments on the subject of sex change in the male papaya, found that the moon's phase has no influence at all on the changing of male papayas to females, as claimed by native Porto Ricans. He found no change in some of his plants, but in others, especially those treated at some recurring periods, some sex change was shown. His conclusion is that the removal of the growing tip causes the change, "but also that some other condition is necessary". He suggests short cyclic periods of development for the plants, adding that decapitation at some definite phase of this cycle may produce the desired change.

Higgins and Holt (1914) mention a few positive cases of sex change in the male papaya as a result of decapitation and state that no operation produces the change unfailingly, as no alteration occurred in the great majority of the seedlings treated. The authors offer the bud variation concept as a possible explanation for this behavior. According to their hypothesis the potentialities to alter may have their inception in the different buds of the plant in the course of its development and topping would only force the development of these buds and thus bring out whatever differences they may have. They contend that such a theory does not include an acceptance of the cyclic development hypothesis or the possibility of altering the sex of all staminate plants.

The spasmodic appearance of hermaphrodite flowers on originally staminate trees—a change from staminate to correae—is considered by Higgins and Holt

as a natural outcome, inasmuch as the flowers of the so-called male tree possess a rudimentary and non-functional pistil, and it is only a question of inducing the normal development of this organ to effect the change. They call this development a primary change of sex.

Hunn (1914), who obtained four alterations out of 22 male plants cut back, explained his results as follows: The two male trees which changed to correae were from a race which had a tendency to the correae form, and the other two which became pistillate and hermaphrodite, respectively, came from a race which had an unusual tendency to fruit bearing as practically all the individuals in this race were either hermaphrodite or pistillate.

Kulkarni (1915), of India, observed three types of sex change in the male papaya. The first consisted in the spasmodic appearance of hermaphrodite flowers among the male flower clusters, very similar to the primary change noted by Higgins and Holt. A few bisexual flowers appeared at some period but no more showed up later on the plant. The second class of change was a distinctly periodic alteration of the sexual expression: the tree was at first staminate, then hermaphrodite, and finally pistillate, with various degrees of combinations between the three main lines. The third type noted by this investigator was that brought about by beheading the tree. He observed only a case or two of this kind of change. With all this body of results Kulkarni reached the conclusion that change of sex is not in any way associated with pruning of the terminal bud.

An investigator in Ceylon (1908) claimed that one cutting back is not always sufficient to produce an alteration and that the tree has to be cut back more than once to make the treatment effective. His explanation for the phenomenon of sex reversal in papaya is that topping brings about a "concentrated or vigorous condition of the cell-sap" which is necessary for the proper development of the ovary.

According to Mr. D. A. Herbert, formerly professor and head of the Department of Plant Physiology of this College, decapitation of male trees for the purpose of transforming them into fruit-bearing forms is a wide-spread practice in Queensland, Australia. The effectiveness of the operation, he said, is now a recognized fact, but whether it would pay in the end remains to be seen.

### *Sex reversal in other flowering plants*

It may not be out of place to mention at this juncture that sex reversal has been found to occur naturally or through experimental control, such as mutilation of parts, subjection to abnormal environment, etc., in a number of dioecious flowering plants. Schaffner (1921, 1923) has obtained extensive data on this subject in hemp (*Cannabis indica* L.), silver maple (*Acer saccharinum* L.), meadow-rue (*Thalictrum dasycarpum* Fisch & Lall.), and some other plants. Prichard (1916), Stout (1923) and a few others reported from Ceylon (1908) and Kew Gardens (1914) also secured alteration of sex in the plant materials they studied. In some cases there were alterations in both directions, from male to female and vice versa. All these investigators contend that their results do not support the chromosome theory of sex determination; and that sex is controlled by some physiological activities of the tissues of the plant and hence alterable by outside external forces.

*Objects of the present work*

This work was undertaken with the following objects in view:

First: To determine whether there exists in papaya seedlings external morphological characters which show maleness, femaleness, or the hermaphrodite condition. It was desired to test the validity of the papaya growers' assertion that some seedling characters are associated with sex.

Second: To study the phenomenon of change of sex in papaya: the best means of effecting it and its possible bearing upon the determination of sex in plants.

*Place and time of work*

The experiments herein reported were conducted at the College of Agriculture, Los Baños, P. I., during the period between April, 1923, and January, 1925. Most of the experiments were performed in the Plant Breeding Nursery of the College.

## MATERIALS AND METHODS

*Varieties used*

Three varieties of papaya; namely, the Dapitan (sometimes also called Brazilian), the Solo, and a native papaya C. A. 17924 (the College accession number), were raised by the writer for the present study. Plants of the Dapitan and Solo varieties were grown from seeds selected from pure female, or pistillate trees, only. Those of C. A. 17924 were from a pentandria fruit of an hermaphrodite tree bearing both elongata and pentandria fruits, the form 8 of Higgins and Holt (*loc. cit.*), and its seeds were the only materials from an hermaphrodite tree planted by the writer.

Besides the plants raised in the Plant Breeding Nursery, papaya plants of different varieties in the College Orchard in the Experiment Station and in cultivated plantations in *caiñgin* lots in the vicinity of the College were studied in connection with the present work. A number of male plants of unknown source scattered in some cultivated backyards were also included in the study.

It may not be out of place to mention here that there are as yet no distinct horticultural varieties of papaya. The so-called "varieties" do not invariably come true to seed; the fruits of a variety, and sometimes even those of one tree, are often distinctly and widely different in shape, thickness of flesh, etc. The variation, as indicated elsewhere in this paper, often depends on the sex of the tree. Hence, as used in this report, the term "variety" should be interpreted in its accepted loose usage. The term "long variety," for instance, is only descriptive; it is often used to designate the hermaphrodite elongata form.

*Germination and pricking*

The washed and dried seeds of the selected fruits were germinated in seed flats or boxes containing rich loam soil, such as is found around bamboo clumps. The soil was sterilized before placing the seeds in it.

The seedlings which appeared in from 10 to 20 days were generally crowded in the box; so when they had from two to four leaves they were carefully dug up and set further apart in boxes containing sterilized loam soil.

*Classification of the seedlings*

At the pricking time the seedlings were grouped into more or less distinct classes, according as they differed externally in foliage (A), in stem (B), and in root (C) characters. At the outset it was observed that some of the seedlings showed fairly conspicuous differences in the margin or lobation of the initial leaves; the color, vigor, and shape of the stem; and the extent and form of the root systems. These conspicuous seedling characters were therefore used as the bases of classification. As additional leaves appeared on the young tender plants the degree of lobation or division naturally became more marked and complicated, but as the variations were only individual and often slight they were not followed further. Several hundreds of seedlings were used in this classification work.

*Classes of seedlings*

*Papaya C. A. 17924.* Class $A_1$-$B_1$: Leaf 1 entire (A), leaves 2 to 4, each lobed on both sides near the base, the leaf appearing somewhat palmately 3-lobed—the terminal lobe plus the two side lobes (plate I, fig. 1); the stem fairly robust and tapering ($B_1$).

Class $A_1$-$B_2$: The same in leaf characteristics as the preceding; but the stem rather slender and not prominently tapering.

Class $A_1^b$-$B_1$: Leaf 1 entire, leaf 2 rather unsymmetrically lobed, on one side only ($A_1^b$) (plate I, fig. 2), the succeeding two or three leaves palmately 3-lobed; the stem fairly robust and tapering ($B_1$) like that of Class $A_1$-$B_1$.

Class $A_1^b$-$B_2$: Leaf characteristics the same as those of the group just described; but the stem rather slender and not promienntly tapering ($B_2$).

Class $A_2$-$B_1$: Leaf 1 entire, leaf 2 also entire ($A_2$) (pl. I, fig. 3), leaves 3 to 4 palmately 3-lobed; the stem $B_1$.

Class $A_2$-$B_2$: The same in foliage as the preceding; the stem $B_2$.

Class $C_1$: Taproot with its minor branches, that is, the main root system long; side root systems much smaller.

Class $C_2$: No distinct primary root system, all the main systems nearly equal in extent.

*Dapitan papaya.* Class B: Stem pinkish purple (leaves not studied).

Class $B_4$: Stem very light green (leaves not studied).

*Solo papaya.* Class $B_3$: Stem pinkish purple. Class $B_4$: Stem very light green.

Class $A_3$-$B_3$: Leaves 1, 2, and 3 entire ($A_3$) (pl. I, fig. 4), leaves 4 and 5 palmately 3-lobed; the stem $B_3$.

Class $A_1$-$B_3$: Leaf 1 entire ($A_1$), leaves 2 to 4 palmately 3-lobed; the stem$B_3$.

*Planting and other cultural treatment*

Seedlings of the pentandria C. A. 17924 were planted on May 27, 1923, and those of the Dapitan and Solo varieties on August 11 of the same year. As the plants were to be observed mainly for their sex and not for their yield, they were set rather close together, 1.5 meters apart each way. There were, in all, 236 seedlings planted in the Plant Breeding lot and each seedling was given a cultural

number: No. 1, No. 2, and so on. As soon as a vacant hill occurred it was replanted with a seedling of the same type as the one that had died. Weeding and shallow cultivation were practiced as often as necessary to keep the place clean and in good tilth.

*Fertilizing male trees*

On October 20, 1923, when the C. A. 17924 plants had been flowering for quite a while, the two male plants, Nos. 92 and 98, of this variety were balled with great care and removed from their poor habitat and transplanted to an adjoining lot which had been fertilized with well rotted stable manure. No other treatment was given the plants except to remove some of the leaf blades to prevent excessive transpiration. The plants were shaded and kept well watered until recovery.

*Methods of topping plants*

On November 30, 1923, when the sex of a number of the Dapitan and Solo papayas was definitely known, several Dapitan male trees were topped, or beheaded at a point just below the lowest flower cluster, this point usually being about midway or slightly higher than midway between the middle and the terminal bud of the stem. This mode of topping is denominated as method A. The position of the lowest flower cluster was easily ascertainable inasmuch as the plants had been producing flowers for a short time only. More males, as they appeared during the following months, were treated in like manner, most of them in December and January. Male papayas in scattered, often out-of-the-way places on the College Campus, were also decapitated at various times. As no sex reversal occurred in the earliest toppings and as more materials for this phase of the study became available in the nursery, and later in the College papaya orchard, the other methods of treatment indicated as methods B, C, D, E and F, were adopted.

Method B consisted in pinching off the terminal bud and also all the panicles of flowers at the very base of the pendent peduncle.

Method C was similar to B except that the panicles of flower clusters were not severed from the tree; they were not in any way disturbed.

Method C consisted in pruning old tall male plants about the middle region of the stem.

Method E consisted in pruning old tall male plants about half a meter or more below the middle section, with the cut sometimes coming as close to the ground as half meter.

Method F was a rather severe treatment given a few vigorous plants. It consisted in cutting off the flowers, leaves, and terminal bud, leaving the beheaded trunk almost bare, with only the stubs of the leaf stalks remaining on it.

Most of the untransformed males received further treatment. A few were topped again and the branches of a good many were cut back one way or another.

Female plants were likewise pruned at various periods by methods A and B. Methods A, D, and E were used in topping hermaphrodite C. A. 17924 plants on May 30, 1924.

*Field observations*

The date of the appearance of the initial flower buds on the young plants and the sex of the flowers developing therefrom were noted. The flowers which

appeared from time to time were examined at frequent intervals to see if any natural alteration occurred in the sex expression of each individual tree.

When the trees had been topped the characters of the new flowers appearing on the old stem and on the newly formed branches or laterals were minutely observed. The number of shoots on each treated branch which bore flowers was recorded.

## EXPERIMENTS AND RESULTS

### *Correlation study*

In line with the first object of this investigation a study of the external morphological characters of the seedlings was undertaken soon after their appearance, as fully described above. The C. A. 17924 plants (Nos. 1-107) began to produce flowers about the end of August and the early part of September, 1923, or about three months after planting. Some of the Dapitan (Nos. 108-160) and Solo (Nos. 161-236) trees also flowered about three months after planting, but many of the replanted hills did not bloom until about four or five months later. The sex expressions of the trees and the number of individuals of the same sex in the different classes are summarized in table 1.

TABLE 1

*Summary of the distribution of the sex forms of the trees planted in the Plant Breeding Nursery*

| FORM NO. | CHARACTER OF FLOWER | NUMBER OF TREES | | |
|---|---|---|---|---|
| | | C. A. 17924 | Dapitan | Solo |
| 1 | Pistillate | 26 | 16 | 39 |
| 4 | Elongata | 55 | 7 | 15 |
| 4, 7, and 9 | Elongata, pentandria, and intermediate | 1 | 0 | 0 |
| 4 and 9 | Elongata and intermediate | 2 | 0 | 1 |
| 8 | Elongata and pentandria | 5 | 0 | 0 |
| 2 | Staminate | 2 | 24 | 9 |
| 3 | Correae | 0 | 0 | 0 |
| Total number of trees | | 91 | 47 | 64 |
| Percentage of pistillate trees | | 28.6 | 34.0 | 60.9 |
| Percentage of hermaphrodite trees | | 69.2 | 14.9 | 25.0 |
| Percentage of staminate trees | | 2.2 | 51.1 | 14.1 |

### *Description of the forms*

The descriptions of the sex expressions of the trees enumerated in table 1 follow.

*Form 1.* This is the female (plate III, fig. 3) of the dioecious papaya. Its flowers, which are rather large, have well developed ovaries terminated by rays or lobes of 5 stigmas, and possess no vestige of stamens (plate II, fig. 1). The corolla consists of 5 petals united at the very base. The flowers are generally borne singly, sometimes in clusters of 3 to 5, on short spikes in the leaf axils. The fruits are of various shapes: subglobose, obovoid, nearly ellipsoid, or oblongcylindric.

*Form 2.* The male is the counterpart of the form just described. The non-fruiting, or strictly male plant produces exclusively staminate flowers (plate III, fig. 2), with rudimentary non-functioning pistils and slender corolla-tubes at the inner throat of which are 10 stamens arranged in two series (plate II, fig. 2). The flowers are fragrant and are borne in crowded clusters in axillary, pendant, cymose panicles. The tree bears no fruit.

*Form 4.* The hermaphrodite elongata tree produces two types of flowers (plate II, fig. 3); namely, the fertile bisexual flower (*a*) and the staminate type (*b*). The hermaphrodite flower is fairly large; it possesses an elongated, almost cylindrical ovary with normal stigmas, the ovary being enclosed in an elongated corolla tube at the inner throat of which are 10 stamens, arranged in the same way as those of form 2. The second type is identical with the flower of the ordinary male tree (form 2) except that its corolla tube is often larger. The two types exist together in the same cluster, which may consist of from 3 to 7 flowers, of which 1 or more may be bisexual, though often not all develop to normal size. In each small cluster the central or terminal flower is always of the bisexual type and the two or four at the sides or below are staminate. The peduncles bearing the flower clusters are short, 2 to 12 centimeters in length. Often, however, the initial flowers on the tree are all staminate and this type of flowers may last for several weeks to a few months, thus resulting in no fruit. The fruits are generally elongated, cylindrical, and pointed at the apex, although a good many may be of other shapes, but all invariably have thick flesh and narrow cavity.

The pollen of the staminate flower of this form was found by Higgins and Holt to be "non-functional"; hence their use of the term hermaphrodite for the tree, instead of the term monoecious which is sometimes used to designate it.

*Form 8.* This form is coexistent with the hermaphrodite elongata (form 4) and hermaphrodite pentandria (form 7, plate II, fig. 4), including the non-functional staminate type just referred to. The functional flowers may be borne together in short-peduncled clusters or they may be in separate clusters, but always with the males, resulting in fruits of two different shapes. The pentandria flower appears to be somewhat similar to the female flower in at least two respects—in the appearance of the corolla and in the size and, often, in the shape of the ovary. The ovary of this form is, however, often quite deeply five-grooved, a long-stalked stamen originating from the base of the very short corolla tube resting in each groove. This condition invariably results in fruits which are prominently ribbed or deeply furrowed, though sometimes the furrowing is confined around the stem end of the fruit.

*Coexistence of forms 4 and 9.* This is another type of hermaphrodite papaya which is identical to form 8, except that in place of the pentandria flowers there are intermediate types (form 9). The two fruit-bearing types of flowers do not always appear at the same time on the tree. The ovaries of the intermediate flowers are frequently distorted in shape. The stamens number from 1 to 9 and may be variously located in the short or the long corolla tube.

*Coexistence of forms 4, 7, and 9.* Well developed flowers of forms 4, 7, and 9, including the non-functional staminate, may exist side by side in the same or in separate short-stalked clusters. Generally the tree is at first of the elongata type, then later it may produce one or both of the other two types.

### *Effect on sex ratio of removing the young taproot*

To find out the validity of the papaya planter's claim that the removal of the taproot of the supposed male seedling causes the plant to become pistillate, the taproots of several seedlings of the Dapitan and Solo were cut off at the point of origin, when the seedlings were planted in the field. The branch

roots were left undisturbed. Some seedlings were planted without any such treatment. Table 2 shows the sex of the plants which received this treatment.

TABLE 2

*Sex expressions of the papaya plants whose taproots were cut off at the time of planting*

| VARIETY OF PAPAYA | NO. OF PLANTS | FEMALE | | MALE | | HERMAPHRODITE | |
|---|---|---|---|---|---|---|---|
| | | Number | Percentage | Number | Percentage | Number | Percentage |
| Dapitan | | | | | | | |
| Treated | 28 | 11 | 39.3 | 13 | 46.4 | 4 | 14.3 |
| Not treated | 19 | 5 | 26.3 | 11 | 57.9 | 3 | 15.8 |
| Solo | | | | | | | |
| Treated | 15 | 9 | 60.0 | 4 | 26.7 | 2 | 13.3 |
| Not treated | 49 | 30 | 61.2 | 5 | 28.6 | 14 | 10.2 |

*Effect of fertilizers on the development of male flowers*

The purpose of transplanting male plants, whose sex was of course already known, in a fertilized soil was to observe whether more favorable soil and nutritive conditions would favor the formation of hermaphrodite or pistillate flowers or both. In a limited way it was a test of the oft-repeated statement that high or favorable nutrition causes femaleness.

*Result.* The two fertilized plants grew vigorously after they had recovered from the shock incident to their transfer. They produced flowers in abundance on the typical pendulous peduncles for several months, from November 20, 1923, to March 28, 1924, when they were treated for another experiment. All the flowers were exactly the same as those borne by the plants before they were moved; there was not a single hermaphrodite or pistillate flower produced up to March 28, 1924.

*The first topping of male plants*

Male plants of different varieties and of varying age and size were topped for the first time with one of the various methods of treatment. Table 3 gives the character of the new flowers and the number of flowered or flowering branches produced by the 88 beheaded trees after the first operation with the different methods. It also shows the age of the plants and the duration of flowering up to the time of topping.

TABLE 3

*Character of the flowers produced after the first topping of male papaya plants*
*Dapitan Papaya (Plant Breeding Nursery)*

| METHOD OF TOPPING | NO. OF TREES TREATED | AGE OF PLANTS WHEN TOPPED | NUMBER OF DAYS SINCE FIRST FLOWERED | NO. OF BRANCHES WHICH PRODUCED FLOWERS | CHARACTER OF NEW FLOWERS PRODUCED |
|---|---|---|---|---|---|
| | | *months* | *days* | | |
| Method A | 2 | 4½ | 9 | 2–3 | Male as before |
| " " | 1 | 4½ | 12 | 3 | " " " |
| " " | 2 | 4¾ | 2 | 1–2 | " " " |
| " " | 2 | 4¾ | 11 | 1–4 | " " " |
| " " | 4 | 4¾ | 20 | 1–5 | " " " |
| " " | 4 | 5¼ | 15 | 2–3 | " " " |
| " " | 1 | 5¾ | 18 | 2 | " " " |
| " " | 1 | 5¾ | 33 | 1 | " " " |
| " " | 1 | 6¼ | 15 | 4 | " " " |
| " " | 1 | 7¾ | 59 | 2 | " " " |
| Method B | 1 | 13½ | 84 | 1 | " " " |
| " " | 2 | 14½ | 53 | 2–3 | " " " |
| " " | 1 | 14½ | 236 | 3 | " " " |
| Total | 23 | | | 51 | No change at all |
| Check | 3 | | 64—301 | 0 | " " " |

*Solo Papaya (Plant Breeding Nursery)*

| | | | | | |
|---|---|---|---|---|---|
| Method A | 5 | 4¾– 8¾ | 15–73 | 2–4 | Male as before |
| Method B | 4 | 13½–14½ | 20–175 | 1–3 | " " " |
| Total | 9 | | | 21 | No change at all |
| Check | 2 | | 84–175 | 0 | " " " |

*Papaya C. A. 17924 (Plant Breeding Nursery)*

| | | | | | |
|---|---|---|---|---|---|
| Method D | 1 | 11 | 215 | 6 | Male as before |
| Method B | 1 | 11 | 209 | 7 | Female and hermaphrodite flowers among normal males on two short-peduncled clusters; all the branches with male flowers on long pendent stalks (Plant No. 92, pl. III, fig. 1.) |

*Solo Papaya (College Orchard)*

| | | | | | |
|---|---|---|---|---|---|
| Method A | 9 | 2¾ | 18 | 2–6 | Male as before |
| Method B | 3 | 5½–5¾ | 80–93 | 3–6 | " " " |
| Method D | 3 | 5¾ | 93 | 4–8 | " " " |
| Method F | 1 | 5½ | 80 | 11 | " " " |
| Total | 16 | | | 71 | No change at all |
| Check | 5 | | 93–195 | 0 | " " " |

*"Long" Papaya (College Orchard)*

| | | | | | |
|---|---|---|---|---|---|
| Method A | 5 | 2¾ | 18 | 3–6 | Male as before |
| Method B | 2 | 5½ | 76–80 | 0–11 | " " " |
| Method F | 5 | 5½ | 80 | 4–15 | " " " |
| Total | 12 | | | 90 | No change at all |
| Check | 4 | | 80–195 | 2 | " " " |

*Male papayas scattered on the Campus*

| | | | | | |
|---|---|---|---|---|---|
| Method A | 8 | 5–6½ | 40–90 | 1–4 | Male as before |
| Method B | 3 | 5–6½ | 40–90 | 2–4 | " " " |
| Method C | 5 | 5–6 | 40–80 | 1–5 | " " " |
| Method D | 4 | 8–15 | 120–280 | 2–5 | " " " |
| Method E | 6 | 18–30 | 350–730 | 2–8 | " " " |
| Total | 26 | | | 64 | No change at all |

[a] The figures for the age of the trees and the duration of flowering are only approximate.

*Retopping of unaltered male trees*

Eight Dapitan and two Solo male trees which showed no change of sex after the first treatment were cut back again, this time below the lowest flowering branch. The results of this experiment showed no change of sex.

*Beheading of the branches of topped and retopped male trees*

Where no sex reversal had been effected by topping and retopping, as was the case in all the trials except one, the branches were next pruned. The branches of each tree were treated as individual plants and sometimes they were topped in different fashions. Table 4 shows the expressions of the new flowers produced as a result of the different treatments employed.

TABLE 4

*Character of the flowers formed after beheading the branches of topped and retopped male trees*

*Trees topped once*

| VARIETY OF PAPAYA | NUMBER OF TREES WITH BRANCHES TOPPED | METHOD OF TOPPING | TOTAL NUMBER OF BRANCHES TREATED | NO. NEW BRANCHLETS ON TOPPED BRANCHES | CHARACTER OF THE NEW FLOWERS PRODUCED |
|---|---|---|---|---|---|
| C. A. 17924 (Plant Breeding Nursery) | 2 | Method B | 3 | 0–2 | Male again |
| | | Method C | 3 | 0–3 | A branch of plant No. 92 had 3 elongata and 1 pentandria among many male flowers. All the branchlets with normal male flowers on long peduncles |
| | | Method D | 3 | 1–3 | Male again |
| | | Total | 9 | 14 | All males except the 4 hermaphrodite flowers mentioned above |
| | | Check | 2 | 0 | No change |
| Dapitan (C. P. Nursery) | | Method B | 9 | 1–4 | Male again |
| | | Method C | 6 | 1–3 | Lone shoot of plant No. 155 bore a few pistillate and hermaphrodite flowers among many males. All flowers on the branchlets males on long peduncles |
| | | Method E | 2 | 1–2 | Male again |
| | | Total | 17 | 24 | All males except the few pistillate and hermaphrodite flowers mentioned above |
| | | Check | 8 | 0 | No change |

*Trees topped once*

| | | | | | |
|---|---|---|---|---|---|
| Solo (Plant Breeding Nursery and College Orchard) | 20 | Method B | 17 | 1–12 | Male again |
| | | Method C | 4 | 1–3 | " " |
| | | Method D | 5 | 1–7 | " " |
| | | Method E | 4 | 2–3 | " " |
| | | Total | 30 | 70 | No change at all |
| | | Check | 36 | 0 | " " " |
| "Long" Papaya (College Orchard) | 9 | Method B | 11 | 1–10 | Male again |
| | | Method C | 2 | 1–2 | " " |
| | | Method D | 2 | 1–3 | " " |
| | | Method E | 2 | 1–2 | " " |
| | | Total | 17 | 28 | No change at all |
| | | Check | 30 | 0 | " " " |

*Trees treated twice*

| | | | | | |
|---|---|---|---|---|---|
| Dapitan (Plant Breeding Nursery) | 6 | Method B | 7 | 1–3 | Male again |
| | | Method C | 3 | 2–3 | " " |
| | | Total | 10 | 17 | No change at all |
| | | Check | 2 | 0 | " " " |

*Topping of female and hermaphrodite plants*

For purely experimental purposes female trees (plate III, fig. 3) and hermaphrodite elongata trees were decapitated to find whether or not they would show any transformation in sex expression. No such change was observed.

*Typical after-effects of topping*

Two to three weeks after the operation, shoots, numbering from 1 to 16, sprang up around and below the point of pruning. Not all the branches, however, produced flowers and not infrequently shoots were gradually crowded out of existence by their more robust neighbors. The uppermost branch or two or three branches were usually the most vigorous. This refers equally to the three forms used in experiment: male, female, and hermaphrodite.

*Topped male plants.* The branches and branchlets produced flowers in clusters on long, pendant peduncles (plate III, fig. 3 and 1) like those of the untreated trees. There was no conspicuous difference between the flowers of the branches and the original flowers or those of the untreated (check) plants, except in the three flower clusters (not branches) where some hermaphrodite and pistillate flowers were borne among male flowers.

Another type of inflorescence produced by some of the trees the terminal buds of which had been nipped off as in methods B, C, and F, was that in which the new flowers were borne on rather short stalks, not exceeding 5-10 centimeters in length, and invariably held close together so as to form a dense globose mass (plate III).

This short-peduncled cluster of male flowers was observed to originate close to and above the scar left by the pendulous peduncle of flowers removed at the leaf-axil bordering the wound. The changes in sex expression described below were observed in this type of inflorescence.

*Description of the sex changes observed in the male*

*Plant No. 92.* (plate III). This is one of the two males of C. A. 17924 which were transferred to a manured lot. Both were topped on March 28, 1924, using method B with plant No. 92 and method D with No. 98. Plant No. 98 showed no change whatever, but No. 92 did, at least partially and temporarily.

On this plant on April 23, 1923, or 25 days after the operation, a dense short-stalked cluster of young flowers were seen developing at the leaf-axil situated at the lower end of the slanting wound (plate III, fig. 1). Evidently it was not a flower cluster of any branch, for there was no shoot at that point. The cluster was at the seventieth node, or leaf-axil, counting from the very base of the stem. The flowers, apparently, were of various types: some pistillate, a few hermaphrodite, elongata and pentandria, and many staminate. At leaf-axil 69 was a robust shoot with young male flowers about to develop on long peduncles. There was at this time no shoot or flower cluster at axil 68. At axil 67 was another dense mass of flowers (plate III, fig. 1) which were as varied in their expressions as those at axil 70. There were shoots at axils 66, 65, and 64 bearing on long stalks young clusters of male flowers exclusively.

Later observations showed that the flower cluster at axil 70 had 11 pure pistillate flowers, 2 normal elongata, 1 elongata with an imperfectly developed stigma, 2 normal pentandria, and 2 intermediate. These flowers were located at various points in the cluster, and one or two of them, possibly, surrounded with several normal male flowers. Nearly all of the pistillate and hermaphrodite flowers set fruits (plate III), but only two pistillate fruits and one intermediate developed to a fairly large size. The two pistillate fruits were found to be seedless. The seediness or seedlessness of fruits produced as a result of sex change

is a point which investigators of sex change in papaya have failed to note generally.

The flower cluster at 67 comprised 4 pistillate, 5 pentandria, and 2 elongata flowers among many males. These flowers fell off prematurely.

The shoots at nodes 69, 66, 65, 64, and a new one at axil 68 and two others about the base of the trunk, continued to produce only male flowers on the typical pendulous peduncles up to November 11, 1924, when nearly all were cut back for further observations.

*Branch at node 68 of plant No. 92.* Of the six pruned branches of this tree, the one at node 68 showed some temporary change. This branch and another one much lower on the stem were both cut back according to method C, but the lower branch remained staminate like the other four branches. The branch at node 68 formed a dense short-peduncled cluster of flowers just at the edge of the wound made by topping, similar to that shown in plate III, fig. 1. The cluster consisted of three elongata flowers, one pentandria, and all the rest staminate. The bisexual flowers soon dropped off and no more appeared.

*Branch of plant No. 155.* This tree was first topped on December 18, 1923, but the result was negative, that is, it did not alter in sex. Its lone branch was beheaded according to method C and a few months later a dense cluster of flowers consisting of 2 pistillate, 2 elongata, 1 pentandria, and many male, was formed at the foot of the long pendulous panicle of male flowers which was not pinched off from the leaf-axil. Three of the flowers set fruits which soon rotted at the stem end and dropped off. All the young fruits contained numerous seeds. The flowers on the branch when last examined were staminate.

## DISCUSSION OF RESULTS

### *Non-correlation between sex and certain seedling characters in papaya*

An examination of the data obtained showed that the seedlings comprising any one of the classes studied turned out to belong not to one sex form only, but to two or more forms, and that many of those showing somewhat opposite external characters were of the same sex. In the variety C. A. 17924 all the classes, whether they were characterized in the seedling stage by having in the second leaf two side lobes or only one side lobe ($A_{1b}$) or no lobe at all ($A_2$); or whether they had a robust, tapering stem ($B_1$) or just the opposite—slender and not distinctly tapering ($B_2$); or whether they had a major central root system ($C_1$) or none ($C_2$), turned out to be quite predominantly hermaphroditic and to some extent pistillate. There were only two male trees of C. A. 17924 and these were in Class $A_2$-$B_2$. These males might at first be taken as being associated with the character $A_2$ or $B_1$, but as the classes in which these characters were likewise found, as in $A_2$-$B_2$, $A_1$-$B_1$, and $A_{1b}$-$B_1$, had not a single male representative, such an inference can not be maintained for lack of confirmatory support. In addition, the very high percentages of fruit-bearing forms in the different classes remove at once the possibility of such an association. In variety Dapitan the two almost opposite classes $B_3$ and $B_4$, as well as the check lot, comprised about equal percentages of pistillate and staminate trees and to a less extent, elongata. Curiously enough, the same classes of Solo showed no male individual among them at all. The other groups of this variety were strongly pistillate and to a less degree staminate and hermaphroditic.

All these results point out that the lobes of the initial leaves, the color or vigor of the tender stem, and the presence or absence of a taproot in the papaya seedling are not in any way indicative of the future sex of the tree. For, as far as the above external characters are concerned, not one of them or set of them is wholly or even to any extent connected with one particular sexual state, such as femaleness or maleness. And a vegetative character to be associated with sex or to be a secondary sexual character must be "an invariable or almost invariable accompaniment" of that particular sex (Babcock, 1918). Certainly a character can not be a distinguishing feature of one sex when it is also possessed by the opposite sex. It may be possible that the character being sought does not appear until later, but the apparent external likenesses of numerous maturer trees of the different sexes precludes such assumption.

It is thus seen that the beliefs and suppositions entertained by some papaya planters concerning the differences in the external characters of the roots, stem, and initial leaves of female and male trees while in their seedling stage have no foundation of fact. To be sure, the average grower sets his seedlings in the field indiscriminately, not usually noting whether all their leaves or only some of them are lobed, or whether or not they have a taproot. When later he finds quite a few males but many fruit-bearing forms in the orchard he at once, and often superstitiously, associates the appearance of the males with some more or less distinct characters or marks which he may remember to have seen in some of them at planting time, although these plants may not be the ones which showed the marks. Again, some farmers do not transplant seedlings, but establish their papaya orchards from seed planted in permanent positions in the field. The writer has seen two plantations said to be established in this manner, and the percentages of pistillates and hermaphrodites in the field are just as high as those in the orchards planted to seedlings supposedly destined to be of these forms.

*Preponderance of females and hermaphrodites in papaya orchards*

It is a noteworthy fact that the papaya orchards established by the farmers on newly cleared lands, both level or sloping, in various localities close to the College grounds and also in the towns of Bay and Calauang are predominantly fruit-bearing. These orchards consist generally of the long-fruited hermaphrodite elongata and the pistillate forms. Male trees are only occasionally met with among the rows of fruiting trees. However, as soon as they can be ascertained the farmer invariably cuts down most of his male trees. The males in two young orchards surveyed by the writer in Masaya, a barrio of Bay, and one near the College Campus were few and far between. That this condition can not be taken as proof of the growers' claims concerning their ability to pick out the female from the male seedlings is borne out by the fact that none of the characters which they allege to be associated with sex has been found to show such correlation, as stated in the preceding paragraph.

It may be asked, what is the probable cause of the apparent predominance of fruit-bearing forms in these native orchards? The source of the seed might give a clue in answering the question. Some farmers select the long, almost cylindrical thick-fleshed fruit which they call the "Hawaii" type as source of seed and which evidently is the hermaphrodite elongata (form 4). Higgins and Holt, of Hawaii, observed that out of 35 plants grown from seeds of this type of fruit,

34 were hermaphrodite like the stock and only one was staminate. This experiment was continued in Hawaii, using seeds of two fruits which had developed from two hand and self-pollinated flowers of one of the above elongata trees, and the final results by Hunn (1914) are as follows: Of the 435 flowering trees 95.4 per cent were fruit-bearing, exclusive of correae,[4] 1.1 per cent correae, and 3.5 per cent staminate. In the present study of the 107 C. A. 17924 trees which, as indicated under the topic "Varieties used", were raised from seeds of an hermaphrodite pentandria fruit, 97.8 per cent came out to be fruit-bearing and 2.2 per cent staminate. All these results emphatically show that the use of hermaphrodite fruits, especially the elongata type and possibly also the pentandria, (the former is to be preferred because it has a thicker flesh than the latter), as sources of seed is quite promising in eliminating males in the orchard. Hence, in the orchards established by farmers it is not surprising that the fruit bearing trees predominate, for, knowingly or not, they plant seeds which have a strong tendency to be fruit-bearing as hermaphrodite and pistillate.

*Secondary sexual characters in plants*

Mention has been made that none of the characters in the papaya seedlings studied proved to be a secondary sexual character. An anonymous investigator in Ceylon (1908) wrote that the male tree has a characteristic weakly nature. In the writer's observations, however, no such alleged difference in the two sexes was noted. Vigorous, healthy trees might be females, males, or hermaphrodites; and the same was true with the weakly specimens. Evidently little is known about the occurrence and nature of secondary sexual characters in dioecious flowering plants. Merrill (1912) in his descriptions of the dioecious species he had met makes no mention as to whether or not individuals of opposite sex show vegetative dimorphism. Nevertheless, vegetative dimorphism is exhibited by the dioecious *Cannabis indica* L., the female producing a much denser foliage with larger leaf blades and more numerous leaflets, and more robust but shorter stems than the male, as reported by Prichard (1916) and Schaffner (1921).

*Effect on sex ratio of removing the tender taproot*

Contrary to the belief of some papaya growers, the removal of the central root systems of papaya seedlings did not in any way alter the probable ratio of the different sexes to a ratio largely or wholly pistillate. The almost perfect equality of the treated (root pruned) and untreated lots of Solo with respect to percentage of females, etc., as shown in table 2, is a strong case in point. With the Dapitan, the higher percentage of females and the lower percentage of males in the treated lot as compared with the proportion of sexes in the untreated lot may seem to support the farmers' claim, but the differences can not be considered significant. Besides, in this same variety there were still more males than females even after the operation, additional evidence as to the unfounded character of some of the growers' beliefs concerning sex in papaya.

[4] This form is identical to the ordinary male tree except that some of its flowers have well developed functional pistils, resulting in fruits which are generally small in size, borne on long drooping peduncles. The bisexual flowers are identical to the elongata except that their ovaries are much smaller and not as elongated.

*Topping and sex change in the male*

As may be seen in table 3, only plant No. 92, out of a total of 88 male trees of varying stages of development which were topped in six different ways, showed alteration in sex expression after the first treatment. The change consisted in the appearance of several pure pistillate and three types of hermaphrodite flowers among normal male flowers on short-peduncle clusters. But the change was only partial and temporary. Partial, or incomplete because the new shoots or branches were exclusively staminate in their expressions, besides, as just noted, in the same clusters with the fruit-producing flowers were masses of male flowers; and temporary, because when the fruit-producing flowers were gone, no more of these types appeared on the tree during the succeeding 276 days. It made no difference by what method the other 87 trees were pruned, they continued to bear male flowers as usual. It is evident, therefore, that topping, in almost any form, as a means of transforming male papayas into females or hermaphrodites, is very uncertain and wholly impractical, for only a few of the pistillate and hermaphrodite flowers produced after the operation set fruits. And most important of all, at least from the grower's standpoint, the branches which would subsequently form the top of the tree remained staminate. The first case of sex change through topping noted by Iorns (1908) appears to be incomplete as were those just noted; so also one of the two changes secured by Kulkarni (1915). Higgins (1913) reports no instance of transformation to the pistillate condition in a lot of beheaded young male trees, although there appeared to be an increase in the number of hermaphrodite flowers borne. Nevertheless, one or two out of the four alterations observed by Hunn (1914) seem like complete reversals, one from male to pistillate and the other from male to elongata. Higgins and Holt (1914) also mention a case of a male becoming completely female through the accidental removal of its top. But where some more or less permanent change was noted the percentage of such response was very small.

The suggestion is made by a Ceylon worker (1908) that the male tree has to be cut back more than once to secure a reversal to the pistillate condition. But no change was shown by the ten male trees which were retopped several centimeters below the old wound. This shows that the scheme of retopping was not very effective in bringing about the desired sexual transformation.

On the other hand, two alterations were obtained with a second form of retopping; namely, the decapitation of the branches. Pruning the branches of trees which had already been treated twice did not, however, produce any change. The results of these treatments are given in table 4. As with the first alteration noted in plant No. 92, the changes produced by two of the 83 beheaded branches were incomplete and transient, not one of the new branchlets becoming pistillate or hermaphrodite in expression. This conclusively shows that not even a second and a third operation will convert the males into females or hermaphrodites, completely and permanently. There might occur an occasional change after these subsequent treatments, but the response can never be relied upon as permanent.

As may be noted again in table 3, the change first shown by plant No. 92 was effected by the method B treatment, and this was the only positive response in 64 toppings by this method. Table 4 shows that the two sex modifications noted on two separate branches were the results of the method C treatment.

Both methods B and C consisted in simply pinching or nipping off the terminal bud, the only difference being that with B the flower clusters below the wound were removed, whereas with C the clusters were left undisturbed. Methods A, D, and E, which are more severe forms of pruning than methods B and C, proved wholly ineffective. This statement, however, does not necessarily presuppose a change of sex in every tree cut back just below the terminal bud. It is possible that the more active and vigorous condition of the cells around the growing tip as compared with those much lower in the stem, may be partly responsible for the apparent differences in the sexual manifestations of the trees which were merely pinched back below the bud and those pruned rather severely.

The beneficial effects of the application of manure on plant No. 92 could hardly have any connection with the sex change exhibited by this plant. At least, as indicated elsewhere, no such response took place before the beheading treatment. Also, the other male tree similarly manured, but differently pruned, developed no change before (or after) the operation. Plant No. 155 was not manured—and was quite stunted—nevertheless it showed some change. From these rather meager data a tentative conclusion may be deduced; namely, that the male tree of already known sex, even when grown under quite favorable soil conditions, does not undergo any sex alteration, such as the production of pistillate flowers. Darling (1909) wrote "that in strictly dioecious forms such factors (referring to differences in nutrition supplied) do not determine, at least in the life history of the individual, which sex shall develop."

Iorns' (1908) theory about short cyclic development in male papayas apparently finds no support in the results of the present work. Table 3 indicates that the trees beheaded were of varying ages: 2¾ months, 4½ months, 4¾ months, 5¼ months, and so on at irregular lapses to about 30 months. The Dapitan and Solo trees in the Plant Breeding Nursery ranged in age from 4½ to 14½ months at the time of the operation; the Solo and "Long" trees in the College Orchard from 2¾ to 5½ months, and so on. Again, in some cases not all the trees of the same age had been producing flowers for the same number of days up to the time of decapitation, a fact which further narrows down the duration of the supposed cycles. And yet only an 11-month old tree (No. 92) exhibited a modification in sex expression after the first operation. That this is not likely the susceptible phase of the cyclic periods, if there be such, is evidenced by the fact that all the other trees of nearly the same age as the above, remained unaltered. The same is also true with the other two changes.

In quite a similar manner the present results appear to be not in harmony with the bud variation hypothesis which Higgins and Holt (1914) suggest as a possible explanation for this type of sex change in the male. As has been mentioned more than once in this paper, none of the branches formed on and along the beheaded trunk or the branchlets arising from the pruned primary branches, which of course had their origin in the axillary buds, manifested any change. The few and slight alterations observed did not take place in these forced axillary branch-buds, but rather in isolated and localized parts in the semi-staminate inflorescences which developed independently of the vegetative shoots. In accordance with this theory it is some of these side shoots that should exhibit the variation in sex expression that may occur after the beheading treatment. Furthermore, table 3 shows that the number of branches which flowered in each

tree was from one to as many as 15, none of which showed any sexual variability. It seems obvious that the observed changes do not appear to come under the category of bud variation.

*The female and hermaphrodite in sex change*

Mention has been made elsewhere that the female papaya has not yet been seen to change its sex (Higgins and Holt, 1914). The data obtained in this work constitute a direct evidence that decapitation does not alter the expressions of female trees. Not a single one of the 62 beheaded specimens which were of varying ages at the time of the operation exhibited any modification in sex, all their branches producing exclusively pistillate flowers the same as the normal untreated trees. This apparently shows that the female is sexually stable, a conclusion that might be inferred from the character of its flower, which is purely pistillate with no indication of even a vestige of any male organ. In this respect the female papaya plant is unlike the female plants of *Cannabis* and *Thalictrum* which are reported to manifest ready and often considerable reversion to the opposite sex through mechanical injury or through abnormal cultural environment. This apparent stability in the sexual state of the female papaya has, of course, the economic advantage that there would be no fear of the tree's becoming male and hence non-fruiting, should its top be accidentally injured or removed.

As far as the results go, the prevailingly hermaphroditic condition of elongata trees appears fixed, stable, like the pistillateness of the female tree. The non-appearance of bisexual flowers in the individuals treated by methods D and E during a period of 188 days does not necessarily indicate that they have become completely staminate, because the hermaphrodite papaya, as has been shown, has the curious behavior of often producing its non-functional staminate flowers exclusively at certain seasons, especially during its early period of flowering. Incidentally, it may be noted that the two methods caused a marked stunting and even death of some of the plants thus treated; a condition which possibly accounts for the non-production of bisexual flowers in many of the trees.

*A genetic mechanism of sex change in papaya*

The theses of the two main and rather opposed theories of sex determination in plants including the evidences supporting them are presented in the first part of this paper. As ordinarily interpreted the chromosome theory of sex does not admit that sex development is influenced by environmental factors, whereas the physiological theory disregards chromosomes in the matter of sex inheritance. However, the opinion is held by some that the two hypotheses are not really contradictory, if properly interpreted. Coulter (1923) is inclined to believe that they "express the same fundamental facts in different terms." Emerson (1924) makes the strong assertion that the development of sex, like other characters, is influenced by genetic factors and environmental agencies in co-operation. Yampolsky (1919) agrees with the opinion that sex characteristics and anatomical and physiological characters have the same type of inheritance. The recent work of Bridges (1921) with *Drosophila* seems to point out that a number of factors may operate in conditioning maleness or femaleness.

With this background, the behavior of sex in papaya may be interpreted in its proper light. While it has not been shown by cytological or thorough genetic

studies that the papaya exhibits the simple sex chromosome mechanism or otherwise, the sex of this plant may be assumed to be on the basis that female-inducing and male-inducing factors, which may be located in different chromosomes, are present in its tissues and that some physiological stimuli may unsettle the balance between the two sex influences. The purely unisexual condition of the female tree and its proved tendency to remain stable and not to mutate vegetatively even when subjected to the unusual physiological stimulus of topping, seem to suggest that the net effects of the sex influences are very strongly toward femaleness.

The rudimentary pistil in the ordinary staminate flower is quite suggestive of the presence of female-inducing factors in addition to the male-inducing factors in the somatic tissues of the plant. Under ordinary varying conditions of environment the balance between the two opposite sex tendencies is prevailingly toward the male side. It may be possible that in some scattered cells or tissues of the stem or of the inflorescence of the male this balance is in a fairly delicate situation so that an unusual physiological agency, such as may follow the stimulus of pruning, might upset the normal relation between the female-inducing factors and the male-inducing factors. This was likely the situation in the three cases of localized and brief sex alterations observed, in which the direction of the change was from male to hermaphrodite in some scattered parts of the staminate inflorescence and from male to female in other parts. But, as has been intimated above, pruning is not the only agency which may produce unusual physiological states that unsettle some cells, because fairly similar types of changes in the male are occasionally observed in nature. The changes just referred to are those from male to correae and from male to forbesii.[5] In any event it is apparent that the balance of the opposing sex tendencies in some scattered parts of the staminate inflorescence may be delicately situated somewhere between femaleness at one end and hermaphroditism at the other end, and that an unusual stimulus would throw the situation one way or the other, resulting in female flowers or in hermaphrodite flowers as the case may be. Higgins and Holt mention the fact that the bearing of fruits by male trees "takes place most freely in cool climates outside the Tropics or at high altitudes". This seems to show that the cool weather in such situations furnishes the principal stimulus in causing the sex changes. Coulter (1923) recognizes that unusual extrinsic physiological agencies may cause a male individual to become female or vice versa.

The particular rearrangement that takes place in the chromosome outfit of the cells or tissues of the staminate inflorescences which showed the sex changes, is unknown. It is not impossible that the changes result from an irregular mitosis of the disturbed cells, with a consequent uneven or abnormal distribution of the chromosomes carrying the sex factors. Such changes are often called factor mutations, but, as already pointed out, are not bud variations, at least in the strict horticultural sense.

[5] Forbesii is the form 6 of Higgins and Holt (1914). This form is identical to the ordinary male tree except that it bears some functional female and hermaphrodite pentandria flowers among the male clusters. The writer has observed the correae and forbesii types of papaya on the College grounds, but not in his cultures.

## SUMMARY OF CONCLUSIONS

1. The margin of the initial leaves, the color and vigor of the stem, and the size or extent of the root systems of young papaya seedlings are not individually or collectively associated with maleness or femaleness. This conclusion is contrary to the current beliefs of papaya growers regarding the existence of such an association.

2. The preponderance of fruit-bearing forms in papaya orchards located in the vicinity of Los Baños is due mainly to the use of seed of hermaphrodite elongata fruits for planting purposes. This suggests an effective method of eliminating males in the plantation.

3. Cutting off the central root systems of young papaya seedlings did not give any effect on the normal ratio between the male and female individuals.

4. Topping, or decapitation can not be depended upon as a scheme of converting sterile male papaya trees into fruit-bearing forms completely and permanently. It is decidedly impractical. Only one specimen out of 88 decapitated trees showed a change in sex expression, and this change was incomplete and temporary.

5. Even a second and a third topping did not bring about the desired sex transformation. The sex changes produced in 2 out of 83 treated branches were likewise partial and transient.

6. The topping which consisted mainly in pinching off the terminal bud was followed by the slight sex changes observed. The severer forms of topping brought no positive response.

7. Sex change in the male does not appear to be influenced by the stage of growth of the plant. No one stage was found in which the susceptibility of the tree to the stimulus of pruning was greater than at any of the other stages.

8. The localized sex changes in the male do not appear to be bud sports in the strict horticultural sense.

9. The female papaya was not found to alter its sex through the removal of its top.

## ACKNOWLEDGMENT

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## ILLUSTRATIONS

### Plate I

Fig. 1. Type $A_1$: Leaf 1 entire, leaf 2 to 4 each lobed on both sides.

Fig. 2. Type $A_1b$: Leaf 1 entire, leaf 2 rather unsymmetrically lobed on one side only, the succeeding leaves lobed on both sides.

Fig. 3. Type $A_2$: Leaf 1 and 2 entire, leaf 3 and 4 lobed on both sides.

Fig. 4. Type $A_3$: Leaf 1, 2, and 3 entire; leaf 4 lobed on both sides.

### Plate II

Fig. 1. A female flower.

Fig. 2a. A cluster of male flowers.

Fig. 2b. A male flower cut open to show rudimentary pistil.

Fig. 3a. An hermaphrodite elongata flower. Note the stamens at the throat of the long corolla tube.

Fig. 4. An hermaphrodite pentandria flower showing the stamens in the grooves of the ovary.

### Plate III

Fig. 1. A topped male papaya tree (Plant No. 92) which showed a partial change in sex expression after the first treatment.

(a) Ordinary male flower clusters on the typical long pendulous peduncles.

(b) and (c) Short-stalked and dense clusters of male flowers including fruits which developed from some of the pistillate and hermaphrodite flowers.

Fig. 2. A beheaded male tree which showed no change of sex after the first treatment and again no change after pruning the branches. Note the pendent flower clusters.

Fig. 3. In the foreground are two branching and fruiting female trees the expressions of which were not altered after cutting back.

Fig. 1

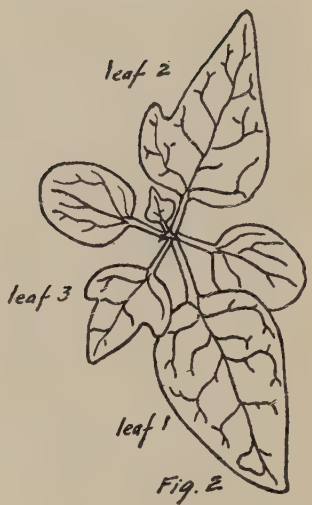


Fig. 2

Fig. 3

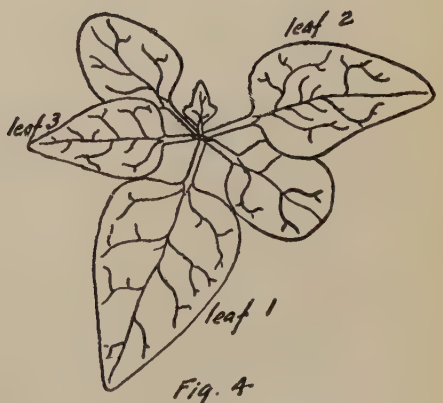


Fig. 4

PLATE I

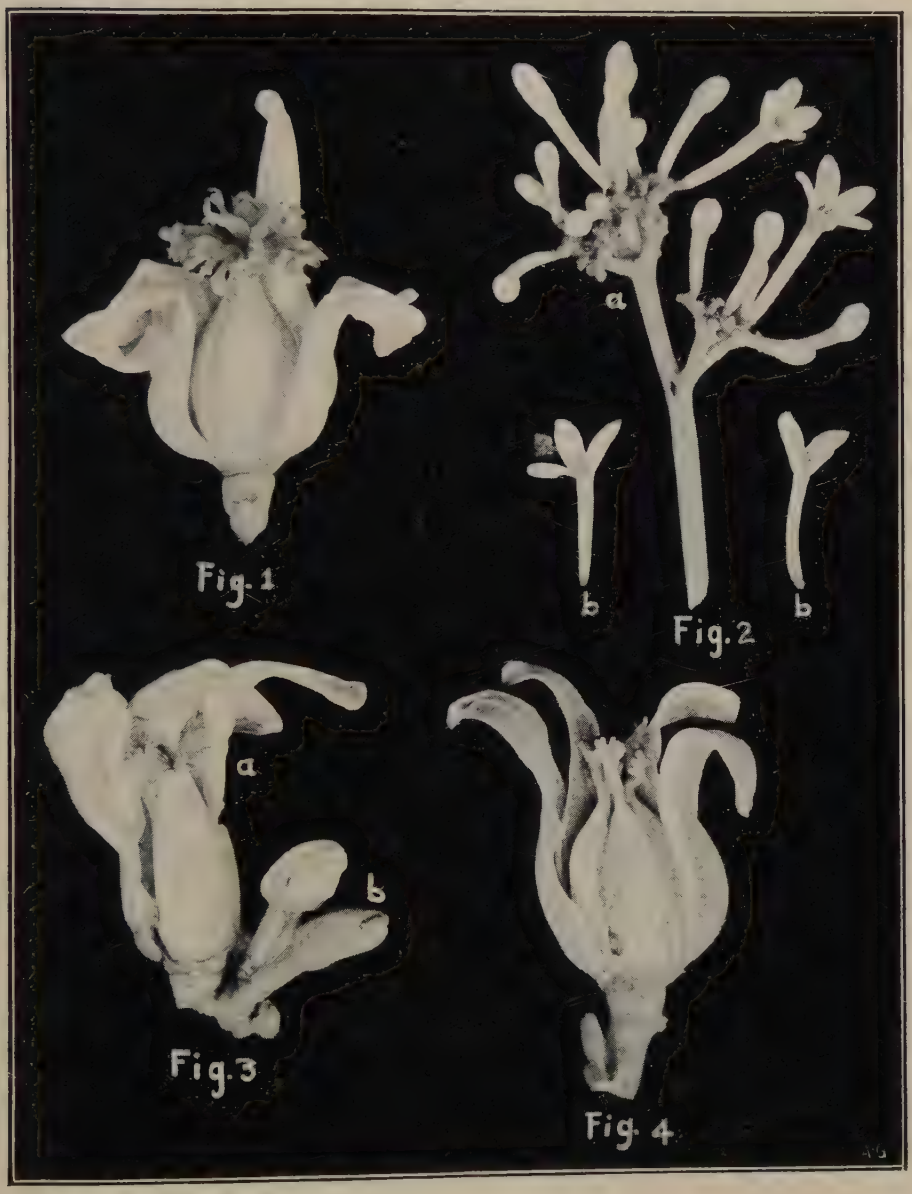


PLATE II

FIG. 1

FIG. 2

FIG. 3

PLATE III

# AN OUTBREAK OF FOWL CHOLERA[1]

A. K. GOMEZ

*Of the College of Veterinary Science*

The poultry industry in the Philippines has great possibilities. It is important, then, that we learn not only about the breeding and rearing of the avian species, but also to recognize the infectious diseases to which they are subject and the methods of combating and preventing these epizootics.

In the United States, poultry diseases occupy a large place in veterinary research work. Specialists in this particular line have evolved and form a group of scientific "chicken pathologists". Recently, veterinary journals have devoted whole issues to the discussions of poultry ailments.

In the Philippines very little, if any, attention is being given to this important field of investigation. For the purpose of awakening more interest in chicken diseases in these Islands, this study of a recent outbreak of fowl cholera is presented.

## HISTORY

Fowl cholera is extensively disseminated in Europe (with the exception of Great Britain), in North America, and in South Africa, causing very heavy losses especially among the finer breeds. The economic value of these losses cannot be estimated. But wherever epizootics of fowl cholera have taken place, the poultry industry of that locality has been materially hampered.

The disease was reported by veterinarians as early as the eighteenth century. In 1851, Benjamin, Delafond, and Renault, and in 1858, Hering, recognized the contagious nature of fowl cholera and substantiated this character experimentally. In 1878, Perroncito and Semmer each described a diplococcus which they frequently found in the blood of fowls dead of cholera, as the possible cause of this disease. In 1879, Tousant, and the year following, Pasteur definitely determined the causative agent of fowl cholera by growing the organisms in artificial media and studying their biological characteristics. Pasteur's fundamental experiments on the production of immunity by injections of attenuated bacterial cultures were first carried out with the microorganism of fowl cholera.

In the United States, fowl cholera was first reported and studied by Salmon. Later, numerous American scientists investigated the disease extensively and among these investigators Hadley's work stands out prominently.

In the Philippines, Fronda (1923) in a survey of poultry diseases in Los Baños, called attention to the prevalence of fowl cholera in this locality. In the clinical records of the College of Veterinary Science for 1922-1923, several cases of this disease are reported. So far as the writer knows, there is no other published reference to this epizootic in the Philippines.

[1]Read before thirteenth meeting of the Los Baños Biological Club on August 27, 1925. Experiment Station contribution No. 324. Received for publication, September 11, 1925.

AUTOPSIES

From December 6, 1924, to March 26, 1925, there occurred heavy losses among the chickens, ducks, and turkeys in the Poultry Division of the College of Agriculture. The dead birds were sent to the College of Veterinary Science for autopsy. The majority of these cases showed lesions pathognomonic of fowl cholera. All of these autopsy examinations are on file in the Department of Pathology and Bacteriology of the College of Veterinary Science; a few only are given in this paper.

On February 19, 1925, dead Cantonese hens B231, B347, B243, all from Pen 9 which registered a heavy mortality, were sent to the College of Veterinary Science for post-mortem examination.

The following lesions were found:

1. Cantonese hen B231: Comb and wattles, bluish black in color; rigor mortis, marked; heart, covered with a fibrino-purulent exudate; pericardium, adherent to the heart muscles; left lung, hepatized and grey in appearance. There were extensive hemorrhages on the right side of the peritoneal cavity; the spleen showed prominence of the Malphigian corpuscles; the liver was light chocolate brown in color and was riddled with pin point hemorrhages throughout. The mucous membrane of the duodenum was petechiated and its contents consisted of a pasty slate grey mass admixed with minute blood clots.

Microscopic examination of blood smears from the heart, liver, and spleen, stained with 1:10 dilution of carbol-fuchsin for three minutes, revealed the presence of bipolar organisms.

2. Cantonese hen B347: Marked rigor mortis; the comb and wattles, cyanotic; numerous petechiae along the coronary region of the heart; presence of a gelatinous exudate tinged with blood in the pericardium; liver, apparently normal; the mucous membrane of the duodenum was reddened.

Microscopic examination of blood smears from the heart, liver, and spleen showed presence of bipolar organisms.

3. Cantonese hen B243: Comb and wattles, cyanotic; rigor mortis, pronounced. The heart was apparently normal; the liver had a cooked appearance and was spotted with numerous greyish white dots of degeneration, varying in size from a pin point to a pin head. The mucous membrane of the small intestine was reddened.

Microscopic examination of blood smears made from the heart, liver, and spleen revealed the presence of bipolar organisms.

On March 14, 1925, a large gobbler was sent to the College of Veterinary Science for autopsy. This turkey was found dead at the roosting place without having shown any previous signs of disease.

The post-mortem findings were: Rigor mortis, marked; the fleshy portion and wattles, cyanotic; heart, petechiated; coronary arteries, engorged; a serosanguinous transudate (30 cc.) present in the pericardium; liver, pale chocolate brown and riddled with greyish white foci of degeneration, varying in size from a pin point to a pin head; mesentery, petechiated and mesenteric arteries, injected; visceral surface of the gizzard showed numerous petechiae; lungs, edematous.

Microscopic examination of the heart blood revealed the presence of bipolar organisms.

On March 18, 1925, a Rhode Island Red hen, B680, was received for autopsy. The findings were: Rigor mortis, marked; crop, full; pericardium contained about 5 cc. of sero-sanguinous transudate; petechiae at the coronary region of heart. A large red coagulum was present in the peritoneal cavity covering the entire liver; this organ showed numerous greyish white dots of degeneration throughout and hemorrhages were found in the membrane of four large ova; the arteries of the oviduct, markedly engorged; the fat on the visceral surface of the gizzard was petechiated.

Microscopic examination of the heart blood revealed presence of bipolar organisms.

On March 25, 1925, a fourth Cantonese hen, B68 from Pen 9, was received for post-mortem examination. The findings were: Heart, petechiated; multiple focal necroses of the liver; this organ was pale chocolate brown in color and friable; congestion of the mucous membrane of the intestines.

Microscopic examination of the blood revealed few bipolar organisms.

On March 26, 1925, a dead Cantonese hen, B59, was received for autopsy. The findings were: Comb, cyanotic; liver, pale chocolate brown, friable and riddled with numerous greyish white areas of degeneration, varying from a pin point in size to a pin head; a large red coagulum was found adherent on the left middle lobe; visceral surface of the gizzard, petechiated; mesenteric vessels, congested. On several ova there were present minute white spots in the yolk, from which pure culture of bipolar organisms were recovered. These ova were also covered with large hemorrhages. The kidneys were enlarged and reddened. Spleen showed no change. The pericardium contained a gelatinous exudate and the heart was petechiated. Lungs, edematous.

Microscopic examination of blood smears from the heart, liver, and lungs revealed the presence of numerous bipolar organisms.

## THE CAUSATIVE AGENT

Pure cultures of *Pasteurella avicida* were recovered from the heart, liver, and spleen of the dead fowls submitted for autopsy. These were cultivated on artificial media and their biological characteristics studied. Organisms from a 24-hour culture on agar slant or from tissues were readily stained with ordinary aniline stains, but were found to stain best by 1:10 dilution of carbolfuchsin allowed to act on a fixed smear for 3-5 minutes. They did not retain the stain with Gram's method. They grew well at 37.5° C.

Under the microscope, the organisms appeared as minute rods, measuring on the average .84 $\mu$ by .42 $\mu$. They showed polar staining.

*Agar-agar.* Colonies, in 48 hours, run in size from a pin point to a pin head. They are translucent greyish white in reflected light, but slightly opaque in transmitted light. The border is entire, surface is convex. Old cultures are slightly coriaceous.

*Stab-agar.* Growth in 48 hours is filliform. Surface growth is convex and small.

*Alkaline bouillon.* Within 48 hours the liquid becomes turbid; after 5 days a stringy thick sediment forms at the bottom of the tube. No pellicle forms, but occasionally a circular band of growth forms at the level of the fluid. No $H_2S$ was detected, even in old cultures.

*Litmus milk.* No change was observed up to 3 months.

*Potato.* Scanty growth within 24 hours, but promptly disappears afterwards.

*Dunham's peptone.* Indol is produced.

### EXPERIMENTAL INOCULATIONS

The disease was easily transmitted to susceptible fowls by injections of the culture or fluids from chickens dead of the disease.

On February 19, 1925, two healthy chickens were inoculated with ½ mil of pericardial fluid from Cantonese hen B347, one traperitoneally and the other intramuscularly. The chicken inoculated intraperitoneally died in 14 hours; the one inoculated intramuscularly, in 18 hours. On autopsy, they showed identical lesions, consisting of petechiated heart and liver and congestion of the mucous membrane of the intestines. The one injected intramuscularly at the breast muscle showed a straw yellow necrotic tract at the path of the inoculation needle. Microscopic examination of the heart blood showed the presence of bipolar organisms.

The chicken inoculated intramuscularly was autopsied immediately after death. About ½ mil of the heart blood was diluted with about 30 mils of sterile salt solution and placed in a sterile bottle. Half a mil of this solution was injected into the breast muscle of a healthy chicken; the remainder was passed through a Berkefeld filter and about 5 mils of the filtrate was inoculated intramuscularly into another healthy chicken. The chicken injected with the filtrate survived while the one injected with the diluted blood died.

On March 20, 1925, two healthy chickens, one a small cockerel numbered E-1, and one a hen numbered E-2, both Cantonese, were placed in an infected cage and fed with infected feed. On March 25, 1925, chicken E-1 was found dead in the cage. It had shown no symptom of disease. Post-mortem lesions were as follows: Fibrino-purulent pericarditis; heart, petechiated; peritoneum, dry; liver, dark brown in color with engorgement of the central veins; mucous membrane of the small intestines, reddened; surface of the gizzard showed few petechiae.

Microscopic examination of the heart blood showed presence of bipolar organisms. Pure cultures of *Pasteurella avicida* were recovered from the heart blood, liver, and spleen.

Cantonese hen E-2 was very sick on this same day, March 25. The following symptoms were observed: Somnolence; sitting continuously in a corner of the cage with feathers ruffled; watery yellowish white feces; anorexia; nervous, when disturbed.

On March 27, 1925, as this hen was very weak, she was killed and autopsy performed immediately.

The lesions were as follows: fibrinous pericarditis; petechiae along the coronary region of the heart; multiple focal necroses of the liver.

Microscopical examination of the heart blood showed presence of bipolar organisms.

The liver, heart, and spleen of this hen were washed with sterile salt solution and immersed over-night in a beaker containing one per cent solution of phenol. The following morning, March 28, these organs were washed in sterile salt solu-

tion, cut into pieces with a sterile pair of scissors and triturated in a sterile mortar and pestle. The mass was then mixed with chicken feed and this was fed to four native healthy chickens numbered E-3, E-4, E-5, and E-6. Two other chickens of the same lot were kept in a separate cage as controls.

Twenty-four hours after feeding, March 29, chicken E-6 was dead and E-4 was very sick, while E-3 and E-5 showed no abnormality in their behavior.

The lesions found in E-6 were as follows: Comb and wattles, cyanotic; sero-sanguinous transudate in the pericardium; petechiae of the heart, edema of the lungs; congestion of the mucous membrane of the small intestines.

Microscopic examination of the heart blood showed presence of bipolar organisms.

The following symptoms were observed in chicken E-4: inappetence; continuously lying down in a corner of the cage; somnolence; temperature 42.6° C. This chicken was found dead in the cage on April 1, 1925, that is, five days after being fed with the infected feed. On post-mortem it showed emaciation; dry subcutis; petechiated heart; ventricles, filled with dark coagulum; liver, friable and passively congested.

On April 3, 1925, chicken E-3 was found dead in the afternoon. No symptoms of the disease had been observed. The lesions on autopsy were petechiae of the heart; congestion of the coronary arteries, edema of the lungs; petechiated liver; congestion of the mesenteric vessels; intestinal contents slate grey and admixed with blood clots; petechiae on the visceral surface of the gizzard.

Microscopic examination of blood smear from the heart, liver, and spleen revealed presence of bipolar organisms. Pure culture of *Pasteurella avicida* were recovered from the heart blood.

The controls and chicken E-5 survived.

On May 6, 1925, a 24-hour agar culture of the organisms was suspended in sterile salt solution and about 2 mils of this was injected at 10:00 a. m. into the pectoral muscle of a native brown pullet numbered E-7. This pullet was found dead at 6:25 p. m. on the same day.

Post-mortem findings were: Comb, cyanotic; rigor mortis, pronounced; heart had a cooked appearance and a few petechiae along the coronary region; a gelatinous exudate was present in the pericardium; left lung, edematous; sero-sanguinous exudate in the pleural cavity. The mesenteric vessels were engorged and content of the duodenum was slate grey pasty mass admixed with blood clots. There was a sero-sanguinous transudate in the peritoneal cavity. The cloaca was markedly reddened and the feces were watery. Pectoral muscles showed at the point of injection a whitish necrotic tract with arborization of the surrounding arterioles. There was present a straw yellow exudate. Liver was pale red in color; spleen, dark brown, and kidneys, swollen and reddened.

Microscopic examination of the heart blood showed presence of bipolar organisms.

Pure culture of *Pasteurella avicida* was recovered from the heart blood.

May 12, 1925. A native brown pullet numbered E-8 was inoculated subcutaneously with ½ mil of this culture. This chicken showed the following symptoms on May 14: Somnolence; anorexia; temperature, 44° C. Red blood corpuscles, 2,984,000 per cc. and white cells, 32,000 per cc.

May 15, 1925, the same symptoms; blood count showed red cells, 2,392,000 per cc. and white cells, 25,000 per cc.

May 16, 1925. The chicken was found dead in the cage. Autopsy findings were: Comb and wattles, cyanotic; rigor mortis, marked; skin at the pectoral region adherent to the breast-bone by a tenacious yellow exudate; anterior half, pale; crop, filled with grains of unhulled rice and oats; pericardial fluid, tinged with blood; epicardium, petechiated at the coronary region; lungs, pale and bloodless; liver, dark brown in color and showed numerous petechiae; also, a few pin point areas of degeneration, gall bladder distended with dark bile; spleen, soft; Malphigian corpuscles, prominent; the fat around the gizzard was reddened; duodenum, pale and contained a yellow pasty mass; fifteen centimeters from the caecum the serosa was studded with parasitic nodules; kidneys, reddened and swollen.

On May 27, 1925, ½ mil of a saline suspension of a 48-hour culture of the organisms was injected into the breast muscle of a pigeon. The following morning, that is, in less than 24 hours, the pigeon died. A typical straw yellow necrotic tract was found along the path of the needle. The pectoral muscles on this side were pale and infiltrated with serous fluid.

## DISCUSSION

Bipolar organisms are usually present in the soil, stagnant water, and decaying plant and animal matter. They are normal saprophytes of the digestive tract and the respiratory passages. Due to certain unknown causes, besides those contributing to a lowered body resistance, these organisms become virulent and successfully invade all the tissues of the animal. After passage through several individuals they acquire such pathogenicity as to give rise to an ensootic or an epizootic. A gradual and sometimes a sudden subsidence of the affection with recurrence after a certain period of time is characteristic of hemorrhagic septicaemia diseases. Thus, an epizootic of fowl cholera may apparently disappear after sanitary measures have been instituted, but break out the following year with more or less increased virulence.

In the outbreak herein discussed, bipolar organisms were recovered from the heart, liver, and spleen of fowls which had died from the disease. Koch's postulates were performed several times and there is no doubt that in this instance we were dealing with an epizootic of fowl cholera. Further inquiry revealed that the disease appears to be endemic among the fowls of the Poultry Division of the College of Agriculture, as from time to time similar outbreaks, although not so intensive as the recent one, had occurred.

Fowl plague can be eliminated, as filtration of the infected blood diluted in salt solution through a Berkefeld filter and injection of 5 cc. of the filtrate into a healthy bird did not reproduce the disease. It will be noticed that the morbid anatomy of dead chickens received for autopsy and that of birds dead from experimental inoculations were practically identical. The lesions correspond in most respects with morbid changes described by various investigators in fowl cholera. It is, however, interesting to note that a fibrinous pericarditis was frequently observed, a lesion not often reported by other writers.

According to Hadley, the straw yellow necrotic tract along the path of the needle noted in the pigeon which was given the injection of a 48-hour culture is characteristic of *Pasteurella avicida*.

The disease was not fowl typhoid, because there was no leukemia present. Also, the cyanosis of the comb and wattles plus the hemorrhagic duodenitis and multiple focal necroses of the liver are diagnostic features of fowl cholera.

The biologic characters and staining qualities of the organisms studied, correspond with those of *Pasteurella avicida*, the causative agent of fowl cholera.

Further studies are in progress with reference to serological reaction of the organisms and their biologic characters in the different sugar media.

## TREATMENT

Treatment of individual fowls is not advisable. As with practically all fowl diseases, prevention is better than cure. Good sanitary conditions should be maintained throughout the pens at all times. There should be a constant personal supervision of the flock in order to determine at once the birds that show the least suspicion of the disease. In introducing new fowls into the flock, they should be quarantined and watched in an isolated pen for at least a month so as to lessen the danger of introducing any disease. The same rule should be observed in the returning of birds from poultry shows.

In case of a severe outbreak of fowl cholera, it is advisable, and will be found to be economical, to kill all sick birds at once and then attempt to save those remaining. The remaining fowls should be divided into small groups and, if the disease appears, that group should be killed. Dead fowls should be cremated or buried with lime deep in the ground. The roosting boards and chicken houses should be thoroughly cleaned and disinfected. Lime sprinkled occasionally on the floors and grounds of infected premises is advisable. Drinking troughs should be attached to the wall in such a way that birds cannot perch on them and soil the water. Sulfuric acid added to the drinking water at the rate of a teaspoonful to a liter of water will minimize possible infection through the digestive tract. The infected pens should be vacated for at least two months.

The poultryman is strongly advised against many of the so-called "fowl cholera cures" as their use is only a waste of time and money.

## SUMMARY

1. An epizootic of fowls, turkeys, and ducks is herein described.

2. The causative agent of this epizootic was found to be the *Pasteurella avicida*.

3. The symptoms of the disease are: (*a*) sudden death; (*b*) high fever; (*c*) somnolence; (*d*) inappetence; and (*e*) general weakness.

4. The morbid anatomy includes: (*a*) cyanosis of comb and wattles; (*b*) petechiae of the coronary region of the heart; (*c*) fibrinous pericarditis; (*d*) edema or hemorrhagic inflammation of the lungs; (*e*) liver riddled with greyish white foci of degeneration varying in size from a pin point to a pin head; (*f*) hemorrhagic inflammation of the duodenum.

5. Good sanitary condition of the pens at all times is strongly recommended.

6. The poultryman is strongly advised against keeping a large number of fowls together in one flock, unless provision is made for dividing the grounds and flock, in case cholera or any infectious disease breaks out.[2]

[2] Hadley.

ACKNOWLEDGMENT

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# SOME ALLEGED PHILIPPINE POISON PLANTS[1]

MOISES M. KALAW AND FRANCISCO M. SACAY

Though the toxicity of many of the native and introduced plants of the Islands is well known, there remains a large number, the poisonous properties of which are partially or entirely unknown. Farmers, *herb larios*, hunters, and fishermen are often familiar with the effects of plants which have been found by experience to be poisonous, though very frequently they are ignorant of the properties of familiar and notoriously toxic species. Some cases in point may be cited. About two years ago there was a high mortality among swine in Lipa, Batangas. The cause was not investigated till the loss became very great. It was noticed that the trouble began after the farmers had adopted the use of copra meal for their pigs. This meal came from two localities, San Pablo (Laguna) and Manila. The pigs fed with meal from San Pablo were unaffected, and it was concluded that this product was better than that from Manila, though no explanation could be advanced. Later it was found that the copra meal from Manila was adulterated with the meal of castor bean (*Ricinus communis*). This contains an alkaloid—ricin—which is left after the oil has been extracted. Before the farmers learnt this they had lost thousands of pesos worth of pigs. Another example of the importance of knowing the properties of common poison plants is the case of a junior student of this College who mistook the seeds of tuba (*Jatropha curcas*) for peanuts. He ate three seeds and after a few minutes had a severe attack of diarrhoea, and only the fact that medical aid was at hand, saved his life.

The object of the present work, which was carried out during the years 1924-25, was the listing of the poison plants in the provinces of Batangas and Bulacan. The common plants have been included, and inquiries amongst herbalists, farmers, fishermen and others, have added a number of species not generally regarded as poisonous. The list, though incomplete, should form a useful basis for future more exhaustive examination. Where possible, field tests for the presence of hydrocyanic acid and of saponin were employed. In the case of hydrocyanic acid, Guignard's method was used; this test is a useful one in the field, though its value for quantitative purposes seems open to considerable doubt.

The province of Batangas varies greatly in its floristic composition, and the work was undertaken in three regions; the first was the coastal region represented by Nasugbu, the second the inland region represented by Lipa and Rosario, and

[1]Experiment Station contribution No. 325.

Arranged by Professor D. A. Herbert, Head of Department of Biology, University of Queensland, Australia, formerly Head of Department of Plant Physiology, College of Agriculture, University of the Philippines. Data taken from two theses: "A Survey of the Alleged Poisonous Plants of Batangas" by Moises M. Kalaw and "A Preliminary Survey of the Alleged Poisonous Plants of Bulacan" by Francisco M. Sacay, presented for graduation, 1925, with the degree of Bachelor of Agriculture, College of Agriculture, Nos. 212; 213. Prepared in the Department of Plant Physiology under the direction of Professor D. A. Herbert.

the third the shore of Taal Lake. Data were collected in the province of Bulacan, principally in Meycawayan, but also in Polo, Obando, Marilao, Bocaue, Santa Maria, Angat, and Norzagaray.

In the following lists the plants are arranged according to their families. The Tagalog names (in parenthesis) were obtained partly from the farmers and partly from Merrill's *Enumeration of Flowering Plants*. The nomenclature adopted in this catalogue is adhered to throughout the paper. A list of publications and unpublished papers on the subject of Philippine poison plants is given in the bibliography:

ANACARDIACEAE

*Anacardium occidentale* (balubad, balubag, balubar, balubat, batubat)

The kernel and fruit are used as food. The oil of the seed causes skin irritation. Coconut oil is used to soothe the affected part.

*Mangifera indica* (manga, mango)

Lard is used to allay the irritation produced by the latex of the immature fruit. Hydrocyanic acid and saponin are present in the leaves, bark and roots, but absent in the wood and fruit.

*Semecarpus cuneiformis* (kaming, ligas)

Used for firewood, and the fruit is sometimes eaten. The leaves and bark cause severe irritation, resulting in blisters. Coconut oil is applied to soothe the irritation.

*Semecarpus philippinensis* (ligas)

The dew on leaves in the morning irritates the skin of most people. There are, however, some quite immune to it. The action seems to be very similar to that of the poison ivy in the United States, the poisonous property of which is due to an oil.

APOCYNACEAE

*Alstonia scholaris* (dita)

Widely distributed in the Philippines. The bark and root are used for medicinal purposes. The latex obtained from the bark sometimes proves fatal to human beings. Water in which the bark is boiled, if drunk, causes abortion.

*Cerbera manghas* (boto-boto)

Stem and root are poisonous. This is not a very common plant in Batangas.

ARACEAE

*Alocasia indica* (biga, elephant's ear)

The juice is an irritant to the skin of man, this property being due to the presence of stinging crystals.

*Amorphophallus campanulatus* (pungapung)

Common and widely distributed in the Philippines. The plant is sometimes fed to hogs. The corm, stem, and leaves produce irritation on the skin of man.

*Colocasia esculentum* (gabi, taro)

In general cultivation throughout the Philippines. The tuber is used for food. The plant produces skin irritation, but this is not very severe.

*Raphidophora merrillii* (tibatib)

Widely distributed in the Philippines. The sap of the plant produces skin irritation.

ARALIACEAE

*Polyscias nodosa* (bungliw)

The leaves contain much saponin. The plant is a popular fish poison.

ASCLEPIADACEAE

*Telosma cordata* (mil-leguas)

The stem, when ground and mixed with feed, causes death of pigs.

FLACOURTIACEAE

*Pangium edule* (pangi)

This plant contains much HCN in bark, leaves and roots, though it was not determined if the effect of plant on fish is due to HCN. It is occasionally used as fish poison.

*Hydnocarpus* sp. (butong manuc)

Bark and leaves are known to be poisonous. This is not a common fish poison. The poisonous principle is unknown.

BROMELIACEAE

*Ananas comosus* (pineapple)

The juice of the fruit has an irritant effect on tender skin.

CAPPARIDACEAE

*Capparis micracantha* (bayabas-uak, dauag, halubagat, halubagat-kahoi, malaruyat-kahoi, salimbagat, tinikan)

The unripe fruit causes dizziness if it is eaten.

*Polanisia icosandra* (apoy-apoyan)

The root causes skin irritation.

CARICACEAE

*Carica papaya* (papaya)

The fruit is used for food. The latex of the plant and fruit is irritating to the skin. Washing the affected portion with warm water and applying a little coconut oil will soothe the irritated part.

CONNARACEAE

*Rourea erecta* (gikos-gikos, guraikan, kamagsa, kamagsa-tagilis, kamunin, palo santo)

The wood, after boiling, if given to dogs with their food, will cause death.

DIOSCOREACEAE

*Dioscorea hispida* (*nami*)

The tuber is rarely used for food. If used, it must be properly prepared by prolonged washing to remove the poison. Unprepared, the tuber, if eaten, causes dizziness and vomiting and sometimes death. Sugar, which seems to be the common antidote for internal poisoning, is administered among Filipinos. When eaten by cattle, pigs, and horses, the tuber may cause death. *Dioscorine* is the substance responsible for the poisoning.

EBENACEAE

*Diospyros multiflora* (canome)

All parts contain poison, but the stem contains the most. This is the most notable poison plant in the province of Batangas. Large amounts of hydrocyanic acid were found in all parts.

ERYTHROXYLACEAE

*Erythroxylum cuneatum* (saleng)

This plant is used as a fish poison in Bulacan.

EUPHORBIACEAE

*Alchornea sicca* (balanti)

The leaves and fruits are used for poisoning fish. Hydrocyanic acid is present in the leaves; absent in the bark and roots; saponin is present in all parts.

*Aleurites moluccana* (kalumban, kapili, lumbang)

Throughout the Philippines at low and medium altitudes, in second growth forests, thickets, etc. The endosperm, when eaten, causes dizziness. Hydrocyanic acid is absent in the leaves, bark, roots, and fruit; saponin is present in the bark and roots; absent in the leaves and fruit.

*Cleidon spiciflorum* (makaisa)

Water in which the leaves are boiled, will cause abortion.

*Croton tiglium* (kamaisa, kamausa, makaisa, tuba, tubang-kamaisa, tubang-makaisa)

Throughout the Philippines in and about towns, usually planted, sometimes naturalized. The plant has no use except as a fish poison, for which purpose the leaves are used. The juice is an irritant; water or lard is used for relief. Saponin is present in all these parts.

*Euphorbia neriifolia* (soro-soro)

This plant is one of the commonest fish poisons, the leaves being employed for the purpose. The sap is a skin irritant.

*Euphorbia tirucalli* (catuit)

Roots and stem are poisonous. The plant is not commonly used. Larger amounts of material are needed to give reliable results. The sap irritates the skin and is dangerous also to the eye. Coconut oil is applied to the skin for relief.

*Excoecaria agallocha* (buta-buta)

Leaves and stem are used for fish poisons. The plant is comparatively rare in Batangas.

*Homalanthus fastuosus* (buta-buta)

The leaves are crushed and put in streams to poison fish. Hydrocyanic acid is absent in the leaves, bark, and roots; saponin is present in all these parts.

*Jatropha curcas* (tuba)

Leaves and stems are poisonous to fish. The kernel, when eaten, may produce death if no antidote is given at once. Sugar is often administered to lessen the effect.

*Manihot utilissima* (kamoting-kahoi, cassava)

The root is used for food. If eaten when not thoroughly cooked, it causes severe headache. Sometimes sugar is given as an antidote, as Filipinos believe that it destroys or neutralizes the poison. The roots have been known to poison pigs. Hydrocyanic acid is present in the leaves, root, and stem, and in Quisumbing's list is noted as the cause of poisoning. Saponin is present in the leaves, root, and stem.

*Phyllantus urinaria* (iba-ibaan)

The stem contains saponin. The plant is not often used because of its comparative rarity.

*Ricinus communis* (lansina, lingan-sina, tangan-tangan)

Important as a source of oil. The juice of the plant irritates the skin, and the seed or kernel, when eaten, produces abdominal pain, drowsiness, and vomiting. Sugar is used locally as an antidote. Sometimes the cotyledon of the seed is burnt and a decoction of the ashes drunk for relief. The seed sometimes causes death of horses and cattle.

GRAMINEAE

*Andropogon sorghum* (batad, sorghum)

Hydrocyanic acid is present in the leaves, stem, roots and fruit; saponin is also present in them. Hydrocyanic acid is the active principle.

GUTTIFERAE

*Calophyllum inophyllum* (dancalan, palomaria)

Throughout the Philippines along the seashore. The leaves are used for poisoning fish. Both hydrocyanic acid and saponin are found in the leaves, bark, and roots.

LECYTHIDACEAE

*Barringtonia racemosa* (putat)

Throughout the Philippines near the seashore. The fruit is used to poison wild pigs. Hydrocyanic acid is found in the leaves, stem, and root; saponin is present in stem and root, but not in leaves.

LEGUMINOSAE

*Abrus precatorius* (banati, kansasaga, kasasaga, saga, saga-saga, saga-mamin)

Throughout the Philippines at low and medium altitudes; common in thickets. There is practically no economic use made of this plant. The seed or kernel, when eaten by man, produces abdominal pain, drowsiness, and vomiting. Sugar is administered to decrease the effect. Hydrocyanic acid is present in the bark, leaves, root, and fruit; saponin is also present in bark, leaves, and root, but not in the fruit.

*Albizzia acle* (akle)

Northern Luzon (Ilocos Sur), southward to Palawan and Negros. The tree is used for building purposes. The bark is principally used in poisoning fish. Hydrocyanic acid is absent in the leaves, bark, and roots; saponin is present in all these parts.

*Albizzia procera* (Ayangaw)

Great amount of saponin in bark and a fair amount on leaves and roots. The plant is a common fish poison.

*Albizzia saponaria* (malatuco, gogo-kasai, gogong-tuko, gugo-tuko, gugong-malatuko)

Northern Luzon (Cagayan) to Mindanao. The tree is used as firewood, and the bark sometimes for cleansing the hair of human beings. The bark is used as fish poison. Both hydrocyanic acid and saponin are present in the leaves, bark, and roots.

*Caesalpina crista* (bayag-kambing, dalagdag, kalumbibit, kamot-kabag)

Throughout the Philippines in thickets along and near the seashore. The seed is sometimes used by *herbolarios* as medicine for stomach ache. When it is taken by human beings in a large amount it causes vomiting. Sugar is used as antidote. In Quisumbing's list it is noted that *bonducin* is responsible for poisoning.

*Derris trifoliata* (sila sila)

A poisonous vine useful as an insecticide and fish poison. It is not very common. According to Pammel, the poisonous principle is derrin.

*Entada phaseoloides* (balugo, tagogo, gogo, gugo)

Northern Luzon (Cagayan) to Mindanao and Palawan. The bark is used for cleaning utensils and for washing the hair of human beings. The bark and also the leaves are crushed and put in ponds and streams to poison fish. Hydrocyanic acid is not found in the leaves, bark, roots, and fruit; saponin is contained in a relatively great amount in these parts. This plant is included in Quisumbing's list with a note that saponin is the active constituent.

*Erythrina variegata* (dapdap, dardap, dasindak)

Throughout the Philippines along the seashore, frequently planted inland. The seed sometimes causes death of cattle and horses when eaten by them. Hydrocyanic acid is present in the leaves, stem, root, and fruit; saponin in the leaves and bark, but not in the root and fruit.

*Millettia splendens* (tubli)

Roots and leaves contain much saponin. It is a very powerful fish poison. The plant is very common.

*Millettia sericea* (botong)

The toxic principle of this fish poison is neither hydrocyanic acid nor saponin. The plant is not common in Batangas.

*Mucuna nigricans* (lipay)

The hairs of the fruits and flowers cause skin irritation. People cannot bathe in water on which the flowers of this plant are scattered, because they so contaminate the water with their trichomes that it produces a very severe skin irritation.

*Phaseolus lunatus* (bulai-patani, buringi, butingi, habichuela, patani)

Common in thickets at low and medium altitudes, ascending to 2,000 meters; some forms cultivated. The plant when eaten by carabaos, cattle, and horses, may cause poisoning. The fruit is used for food for human beings. If eaten when not well cooked, it produces abdominal pain and sometimes headache and vomiting. In some wild varieties it causes death. Hydrocyanic acid is found to be the active principle, and is found in the leaves, bark, root, and fruit; saponin is present in the fruit only.

MALVACEAE

*Gossypium arboreum* (cotton)

Water in which the roots are boiled, if drunk, will cause abortion.

MELIACEAE

*Dysoxylum decandrum* (managtag)

The bark has a great number of tiny hairs which produce skin irritation, especially when dry. Fuel gatherers are often victims. The plant is a common fish poison in Batangas.

MENISPERMACEAE

*Anamirta cocculus* (balasin, bayati, laktang, lanta, ligtang, liktang, summa)

Northern Luzon to southern Mindanao. The fruit is the part of the plant used in poisoning fish. Hydrocyanic acid is present in the leaves, bark, and root; saponin is present in all these parts. This plant is included in the list of Brown.

MORACEAE

*Ficus hauili* (auili, hauili)

The sap is irritant to the skin and produces minute ulcers.

PALMAE

*Areca catechu* (buñga, betel nut palm)

Throughout the Philippines in cultivation. The seed is used for chewing purposes. When taken by human beings excessively, it produces headache and vomiting. Hydrocyanic acid is found in the stem, leaves, fruit, and roots.

*Arenga pinnata* (cabo-negro)

The fruit, when placed in water, after several days is very irritating to the skin of animals.

PIPERACEAE

*Piper celtidiforme* (litlit, lit-lit matsing)

Throughout the Philippines at low and medium altitudes in thickets and forests. When the leaves are chewed by a person not used to it, headache may follow. Hydrocyanic acid is present in the leaves but not in the roots and stem.

POLYGONANCEAE

*Polygonum barbatum* (subsuban)

Leaves and roots are poisonous to fish. The property was not determined. The plant is not very common.

RUBIACEAE

*Randia dumetorum* (sinanpaga)

Leaves and stem are poison to fish. The plant is not very common in the province, so it is not much used.

RUTACEAE

*Lunasia amara* (apdong-kahoi, lunas, pait)

Northern Luzon (Cagayan) to Mindanao and Palawan. The sap is poisonous to man when taken internally.

SAPINDANACEAE

*Ganophyllum falcatum* (panda-panda, gugo, tugabi, tuliba, gogonglangil)

Luzon (Cagayan, Ilocos Sur, Bontok, Union, Nueva Ecija, Pampanga, Bulacan, Bataan, Rizal), Mindoro, Palawan, Tablas, Panay, Guimaras, Negros, Mindanao. The bark of the plant is used for poisoning fish.

*Harpullia arborea* (oas, poas, puas, uas)

Throughout the Philippines in thickets and second growth forests, at low and medium altitudes; usually common. The bark is ground and put in water to poison. fish Hydrocyanic acid is absent in the leaves, bark, and roots, but saponin is present in all of them. This plant is included in the lists of Brown and Quisumbing.

SOLANACEAE

*Capsicum annuum* (sileng-bilog, green pepper)

Throughout the Philippines. The fruit and leaves are used for food. The fruit, if eaten raw by human beings, is very irritating to the mouth. Lard is used to soothe the irritation. Hydrocyanic acid is absent in the leaves, bark, root, and fruit; saponin is present in the fruit.

*Capsicum frutescens* (pasites, sili, Chile pepper)

Throughout the Philippines, wild and cultivated.

*Datura alba* (talong-punay)

Widely distributed about towns in the Philippines. This plant poisons man, producing drowsiness and general weakness.

*Nicotiana tabacum* (tabaco, tobacco)

Cultivated throughout the Philippines, in some provinces very extensively. The leaves are used for smoking. It is narcotic and sometimes produces vomiting and severe headache. Sugar is used to diminish the effect.

UMBELLIFERAE

*Centella asiatica* (taquip-cohol)

Widely distributed in the Philippines. The leaves will cause dizziness if chewed. Neither hydrocyanic acid nor saponin is found in the roots, stem, or leaves.

URTICACEAE

*Fleurya interrupta* (lipang-aso, lipang-kastila)

In cultivated areas, chiefly in disturbed soil at low altitudes in and about towns throughout the Philippines. The trichomes on the leaves produce skin irritation on the skin of man, producing blisters. Oil is used as antidote.

*Laportea meyeniana* (lipa, lipai, lipang-kalabau)

Northern Luzon to Mindoro and Guimaras. The trichomes on the leaves produce severe irritation on the skin of man, producing blisters. Oil is applied on the skin to stop or lessen the irritation. Another practice is to get the cambium layer and rub the affected part.

VERBENACEAE

*Callicarpa formosana* (tubang-dalag)

The plant is used as fish poison. Hydrocyanic acid is not found in the leaves, bark, or roots; saponin is present in these parts.

*Vitex parviflora* (molawin, molave)

Common and widely distributed in the Philippines. The wood of the plant is valuable as a building material. The fruit is ground, and with the bark, is used as fish poison. Both hydrocyanic acid and saponin are present in the leaves, bark, roots, and fruit.

ZINGIBERACEAE

*Zingiber officinale* (luya, gingibre, ginger)

Widely distributed in the Philippines in cultivation. The tuber is used for food. In the raw state it is very irritating to the mouth. Lard allays the irritation. Neither hydrocyanic acid nor saponin are found in the leaves, stem, or tuber.

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# LEAF BLIGHT OF GABI[1]

ELISEO T. GOMEZ

WITH ONE PLATE AND TWO TEXT FIGURES

## IMPORTANCE AND DISTRIBUTION OF THE DISEASE

The leaf blight of gabi (*Colocasia antiquorum* Schott) (*Colocasia esculentum* Schott) often defoliates plants so that the corms are either prevented from forming or are formed abnormally (Mendiola and Espino, 1916). In serious cases, corm infection occurs in the field and in storage.

In the Philippines the disease was first reported by Mendiola and Espino (1916) who state that it is due to *Phytophthora colocasiæ* Rac. The leaf blight of gabi is common in Los Baños, Laguna. Farmers, however, do not usually recognize the disease or pay any attention to it.

Butler and Kulkarni (1913) report that the blight of gabi which has been noted in various places in India since 1905 causes serious damage. The disease was first studied by Raciborski who described the causal organism as *Phytophthora colocasiæ* in Java in 1900. Sawada found the same fungus on gabis in Formosa.

Reinking (1918) found the blight of gabi caused by *P. colocasiæ* prevalent on cultivated and wild gabis in the Philippines. However, no work in detail of the disease and of the causal fungus was made. The disease occurring in southern China is said to be caused by *P. colocasiæ* (Reinking, 1919).

The writer noted that varieties Nagcarlang, Tagalog, Bunglos, and Solo of Philippine gabis were slightly infected by the disease during the dry season and that infection on these varieties greatly increased in the early part of the wet season.

## SYMPTOMS OF THE GABI LEAF BLIGHT

In the early stage the disease is characterized by purplish to brownish, water-soaked, more or less circular lesions on the leaf, varying from one to two centimeters in diameter (plate I, fig. 1). These lesions gradually increase uniformly in diameter. A clear yellowish liquid oozes from the surface of the infected areas on the leaf, especially during damp weather. Sometimes the growth may be faster in one direction on account of the veins, and this results in the production of somewhat elongated spots. The veins often check the growth of lesions for a short time, but soon they cross the veins and continue to develop until the greater part of the leaf is covered.

In the advanced stage of the disease the leaf is covered with irregularly shaped patches of varying sizes (plate I, fig. 2). Often two or more spots unite forming larger lesions and these may ultimately cover the whole or the greater portion of the leaf. Sometimes, rotting leaves may hang on their petioles. Under favorable moisture conditions, rotting extends to the petioles and finally to the corm causing soft rot of the latter.

[1] Thesis presented for graduation, 1925, from the College of Agriculture with the degree of Bachelor of Agriculture No. 214; Experiment Station contribution No. 326. Prepared in the Department of Plant Pathology under the direction of Dr. G. O. Ocfemia.

During the dry season the central portions of the spots assume a yellowish color, become dry, break, and fall off. The lesions are enclosed by yellowish rings. Early in the morning a delicate white fuzz due to the conidiophores and conidia of the fungus is found on this border on the lower surface of the leaf.

## CAUSAL ORGANISM

### *Morphology*

*Mycelium.* The hyphæ of the fungus from field materials are intercellular, non-septate, uniform in outline, containing dense granules of protoplasm when young and becoming less dense as they grow old. Haustoria arise from the hyphæ and run through the inner cavities of the cells of the leaf; these are very conspicuous. The haustoria often curve within the cell cavities.

In pure culture the mycelium is produced on all media aërially and submerged. The aërial hyphæ are non-septate, uniform, smooth, and straight. The aërial hyphæ are granular when young, but the granules become less dense as they mature.

The submerged hyphæ are also granular when young but become vacuolate when old. They differ from the aërial hyphæ in that the submerged fungus threads are larger and more irregular in outline. Septations were observed in very old cultures.

*Conidiophores.* The conidiophores from field materials are borne laterally on the aërial hyphæ. They are short and stalky, bearing a single conidium at the apex. They are hyaline with dense granular contents when young, but the granules disappear with age.

In pure cultures the conidiophores are longer than those from field materials but they present the same general characteristics.

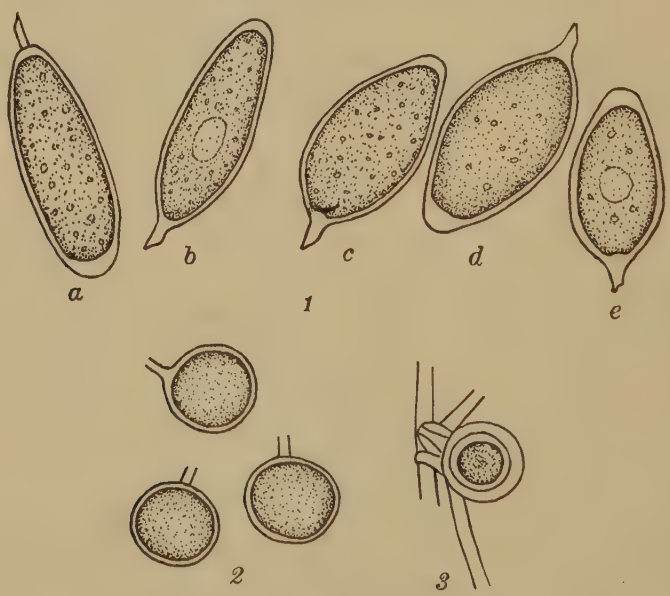


Fig. 1. (*a*), (*b*), (*c*), (*d*), (*e*) different shapes of conidia of *Phytophthora colocasiae*, (2) Chlamydospores. (3) An antheridium and an oogonium produced by *Phythopthora colocasiae* in pure culture on Ashby's Lima bean agar.

*Conidia.* The conidia vary from oval, pear- to lemon-shaped, or elongate (figure 1, *a*, *b*, *c*, *d*, *e*). They are thin-walled, with short blunt papilla at the

free ends. The cell is filled with dense granules of protoplasm when young, and when mature it has a large vacuole lying near and often at the center. The size varies greatly when formed on the leaves in the field.

Measurements of length and width of 200 conidia from field materials were made. Table 1 shows the summary of the results of the measurements arranged according to Rosenbaum's method (1917) in his work on the genus *Phytophthora*.

Table 1 gives the classes made by a difference of two microns and the number of conidia from a total of 200 the lengths and widths of which fall in each class. Measurements of 200 conidia show that the size varies from 38.94-67.16×17.5 28.32 μ. The length of the greatest number of conidia falls in class 58.5-60.49 μ and the width of the greatest number falls in class 22.5-24.49 μ.

Butler and Kulkarni (1913) state that when the conidia are formed on the leaves they vary from 38-68×18-26 μ. According to these authors the size varies within wider limits in culture. Sawada found sporangia (conidia) 114 μ long, but in India the length of sporangia (conidia) recorded rarely exceeds 60 μ.

TABLE 1

*Frequency table showing the summary of measurements of 200 conidia from field materials and 200 chlamydospores from pure culture of the gabi blight Phytophthora in the Philippines*

| CLASS IN MICRONS | CONIDIA | | CHLAMYDOSPORES |
|---|---|---|---|
| | Lengths frequency | Width frequency | Diameter frequency |
| 16.5–18.49 | | 1 | 7 |
| 18.5–20.49 | | 46 | 5 |
| 20.5–22.49 | | 36 | 23 |
| 22.5–24.49 | | 53 | 18 |
| 24.5–26.49 | | 49 | 27 |
| 26.5–28.49 | | 15 | 39 |
| 28.5–30.49 | | | 31 |
| 30.5–32.49 | | | 18 |
| 32.5–34.49 | | | 6 |
| 34.5–36.49 | | | 8 |
| 36.5–38.49 | | | 3 |
| 38.5–40.49 | 1 | | 15 |
| 40.5–42.49 | 1 | | |
| 42.5–44.49 | 4 | | |
| 44.5–46.49 | 5 | | |
| 46.5–48.49 | 14 | | |
| 48.5–50.49 | 10 | | |
| 50.5–52.49 | 19 | | |
| 52.5–54.49 | 5 | | |
| 54.5–56.49 | 35 | | |
| 56.5–58.49 | 18 | | |
| 58.5–60.49 | 42 | | |
| 60.5–62.49 | 11 | | |
| 62.5–64.49 | 30 | | |
| 64.5–66.49 | 2 | | |
| 66.5–68.49 | 3 | | |
| Total | 200 | 200 | 200 |

The conidia are produced in abundance in pure culture where they are more uniformly pear-shaped than in the field, and contain dense granules of protoplasm when young but are vacuolate when old. Papilla are always present at the free ends of the conidia.

*Chlamydospores.* Chlamydospores are frequently produced in pure culture. They are spherical with smooth almost amber-colored walls. They are formed either terminally, or intercalary, by a lateral swelling of the hyphæ. They are developed either at the base of the aërial mycelium or they may be embedded in the media. The chlamydospores are easily distinguished from the conidia on account of the spherical shape and the absence of papilla (figure 1, *2*). Table 1 shows measurements of 200 chlamydospores from pure cultures on potato-dextrose agar.

The diameter of the chlamydospores from pure culture varies from 17.28-38.64 $\mu$. In table 1 it may be seen that the diameter of the greatest number of chlamydospores falls in class 26.5-28.49 $\mu$.

*Oöspores.* Oöspores are seldom produced in pure culture. They were produced on Lima bean juice agar prepared according to Ashby's formula (Ashby 1920). The mature oöspores are almost spherical in shape, and are thick-walled. The thick outer wall is tinted while the inner wall which envelops the oösphere is hyaline. The oöspore is filled with dense granules of protoplasm. The antheridium is present as a swollen thread which is fused with the outer wall of the oogonium (figure 1, *3*).

## CULTURAL STUDIES

Bits of the fungus growth from a ten-day old potato-dextrose-agar culture were transferred to different media and sterilized plant tissues. The behavior of the fungus and the formation of conidia, chlamydospores, and other types of spores were studied.

*Potato agar.* The writer considers potato agar the best medium for the cultivation of the gabi blight fungus. The medium is clear and transparent which makes it easy to detect both the aërial and the submerged growths of the fungus on it. The growth is vigorous with exuberant aërial hyphæ. A week-old culture showed conidia and chlamydospores in abundance.

*Potato-dextrose agar.* This medium had practically the same effect on the development of the fungus as the potato agar. Conidia were produced in one week.

*Clinton's oatmeal agar.* The fungus grew more luxuriantly on oatmeal agar prepared according to Clinton (1909-1910) than on the potato, and potato-dextrose agars. The mycelium on this medium was abundant, cottony, and white. As on the potato agar, conidia were produced after a week. The gabi *Phytophthora* did not produce oöspores on this medium.

*Ashby's Lima bean agar.* This medium had practically the same effect on the development of the fungus as potato and oatmeal agars except that the fungus produced less aërial hyphæ than on these two agars. Conidia were produced in one week. Sexual bodies were produced after two weeks.

*Shear and Wood's corn meal agar.* The writer considers corn meal agar prepared according to Shear and Wood's formula (1913) as the poorest medium for the cultivation of the fungus. Corn meal agar gave practically no aërial growth and only a little submerged growth which spread slowly. The behavior of the gabi *Phytophthora* was practically the same as that of *Phytophthora infestans* studied by Clinton (1908) but no oöspores were produced on this medium. Some peculiar swellings, or chlamydospore-like bodies on the mycelium were produced.

*Oatmeal.* This medium is a good substratum for the cultivation of the fungus. Growth was observed 24 hours after the transfer. Conidia were produced abundantly after a week. Chlamydospores were produced in two to three weeks.

*Corn meal.* Corn meal is not as good as oatmeal because the growth of the fungus on it is slower than that on the oatmeal.

*Sterilized eggplant cylinders.* Eggplant cylinders are good for the cultivation of the fungus but not so good as papaya fruit cylinders. Few conidia were produced in a week.

*Sterilized eggplant stems.* The growth of the fungus on this substratum was slow, but the aërial hyphæ developed more vigorously than on eggplant fruit cylinders. The growth covered the whole tissue extending to the cotton at the bottom of the test tubes. Conidia were produced in one week.

*Sterilized papaya petioles.* The fungus growth on sterilized papaya petioles was also vigorous but less dense than on sterilized papaya fruit cylinders. The growth was rapid, extending to the cotton at the bottom of the test tubes. Conidia were produced in abundance in two weeks.

*Sterilized papaya fruit cylinders.* Papaya cylinders were best for the growth of the fungus. An abundance of aërial hyphæ covering the entire surface of the substratum and ultimately extending to the cotton at the bottom was produced. Conidia were present after one week.

*Sterilized Cucurbita pepo fruit cylinders.* These cylinders had practically the same effect on the development of the fungus as papaya cylinders. The growth was vigorous producing abundant aërial hyphæ. Conidia were produced in three days.

*Sterilized green Vigna catjang pods.* The fungus growth on this substratum was comparatively slow. The aërial hyphæ was scanty, but covered the entire cylinders. Conidia were produced in three weeks.

*Sterilized Capsicum annuum fruits.* Of all the substrata used, this one had the poorest growth of the fungus. The fungus produced scanty aërial hyphæ on the surface of the fruits. Very few conidia were produced in two weeks.

*Sterilized Capsicum annuum stems.* This substratum produced practically the same amount of fungus growth as the fruit. Very few conidia were produced in two weeks.

*Sterilized Lycopersicum esculentum fruit.* The fungus grew more vigorously on this substratum than on *Capsicum annuum.* The aërial growth covered the surface of the cylinders extending to the cotton at the bottom of the test tubes. An abundance of conidia was produced in two weeks.

*Sterilized Lycopersicum esculentum stems.* This substratum produced the same amount of fungus growth as the fruit but fewer conidia were produced in two weeks.

*Sterilized hulled rice.* The fungus growth on this substratum was scanty, producing few conidia after a week.

In the study of the cultural behavior of the Philippine gabi blight *Phytophthora* the writer found that potato agar and potato-dextrose agar are the media best suited for the cultivation of the fungus. These media were used for growing the stock cultures. They are clear and transparent so that it is easy to distinguish the growth of the fungus on them. Ashby's Lima bean agar is a very good medium so far as the production of oöspores is concerned. Corn meal was the poorest, papaya, upo, and eggplant fruit cylinders gave the best growth on the fungus, and pepper and tomato fruit cylinders gave the poorest.

*Spore germination*

The conidia from two-month old pure culture on potato agar were sown in sterile water and melted and cooled potato-dextrose agar.

Butler and Kulkarni (1913) found that germination of the conidia occurs within half an hour after the conidia are sown in water. The writer found that germination of the conidia of the Philippine gabi *Phytophthora* occurs two hours after they are sown in sterile water. The writer also noted that the time required for germination of the conidia varies with the age of the culture from which they are taken. Thirty minutes after the conidia are placed in sterile water, the vacuoles contract. This is probably due to the differentiation of the protoplasmic contents of the conidia, preparatory to the production of zoöspores (figure 2, *a*, *b*, and *c*).

The zoöspores escape from the conidia by moving gradually toward the papillate end and ultimately rupturing the papilla (figure 2, *e*). The zoöspores are twenty or more in number. In sterile water they swim about for a while, come to rest, and then germinate by producing germ tubes. The germ tubes grow and branch for a time on the slide (figure 2, *f*) but they do not form definite mycelium unless placed on a suitable medium.

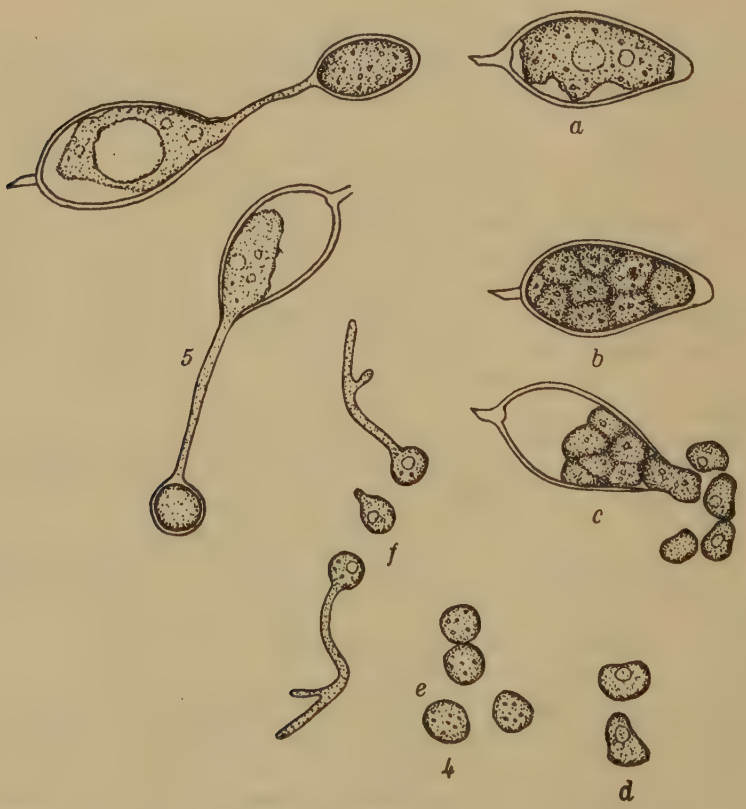


Fig 2. (*a*), (*b*), (*c*), (*d*), (*e*) showing the different steps in the germination of the conidia by the production of zoospores. (*f*) showing the zoospores germinating. (*5*) conidia germinating by the production of germ tubes. One of the conidia produced a chlamydospore at the end of the germ tube and the other produced a conidium.

The zoöspores when in motion are bean-shaped or rather irregular (figure 2, *d*), but when at rest they are spherical or nearly so (figure 2, *e*). Each of these bodies contains a small vacuole. The germination of the zoöspores occurs more than half an hour after their extrusion.

Mounts of conidia which were kept overnight germinated by producing a single germ tube on either side of the papilla. At the ends of the germ tubes secondary conidia were produced (figure 2, *5*). Like the primary, the secondary conidia are vacuolate when they grow old.

On potato-dextrose agar conidia germinated by production of zoöspores, which were liberated six hours after the conidia were sown on it. The zoöspores germinated in a mass about half an hour after liberation from the conidia.

Chlamydospores germinated by the production of germ tubes.

The method of germination of the oöspores was not studied in this work.

*Pathogenicity*

Inoculation experiments were made using pure cultures of the gabi *Phytophthora* grown on potato-dextrose agar. Different varieties of *Colocasia antiquorum* were inoculated both through injuries and on healthy leaves. Inoculations were made by spraying the leaves with conidial suspension in sterile water using atomizers. In the uninjured series the waxy covering of the upper surfaces of the leaves was removed by gently rubbing them with moist absorbent cotton. This was necessary because the upper surface of gabi leaves does not get wet. Care was taken, however, that the epidermis was not injured. Inoculations were conducted in isolated fields and in the laboratory in order to determine whether the fungus would cause trouble similar to the blight of gabi in the field, and to study the relative susceptibility to the fungus of varieties Solo, Bunglos, Nagcarlang, Calamba, Baco, Sanglay, Silañgan Pula, Tagalog, and Kinuaco. These gabis were planted, in isolated fields and in pots. Besides gabis, yautia (*Xanthosoma sagittifolia*) and *Caladium* spp. were used in inoculation experiments. Eggplant, pepper, tomato, citrus (*Citrus medica*), papaya (*Carica papaya*), *Synedrella nodiflora*, and *Corchorus acutangulus*,[2] were used in cross-inoculation experiments.

In other inoculations bits of mycelium from pure culture on potato-dextrose agar were applied on disinfected leaves and petioles of gabis. After inoculations in the field, the inoculated plants and the checks were covered with glacine paper bags. In the laboratory, the plants inoculated and their checks were placed in the moist chamber.

The writer found that infection in the field became evident five days after inoculation while under damp chamber conditions infection took place in one and one-half days. In all inoculations and re-inoculations it was found that all of the gabi varieties used were susceptible to the disease. The susceptibility varied to a certain extent, variety Nagcarlang was found most susceptible. Infection in the field is less severe than in the moist chamber on account of the less humid atmosphere around the plants.

In inoculations and re-inoculations without wounding the plants it was noted that the fungus is able to infect gabi without the plant's being injured.

[2] The writer wishes to thank Dr. E. Quisumbing of the Department of Plant Physiology for the determination of the last two specimens.

The degree of infection was practically the same in all varieties, although Nagcarlang appeared the most susceptible to the disease.

In inoculations and re-inoculations, by spraying the leaves with conidial suspension in sterile water in the moist chamber in the laboratory it was found that all varieties used were equally susceptible to *Phytophthora colocasiæ*.

Cross-inoculation experiments using pure cultures of *Phytophthora colocasiæ* gave negative results. From these results it appears that *P. colocasiæ* is confined to *Colocasia antiquorum* Schott. The results seem to suggest that in the Philippines rotation is a promising means for controlling gabi blight.

Inoculation experiments have also shown that if *P. colocasiæ* is on or within the corm and in the soil it is capable of infecting gabis.

### *Pathological anatomy*

By placing conidia and chlamydospores of the fungus on healthy leaves it was noted that germ tubes gained entrance through the uninjured epidermis, through injuries, and through the stomata of the leaves. The mycelium develops intercellularly in the spongy parenchyma cells of the leaf tissues and the conidiophores are pushed through the stomata.

The spongy parenchyma cells were often penetrated by haustoria. The cells which were surrounded by the fungus mycelium still had chloroplast in them showing that the fungus does not destroy them at once.

### *Taxonomy*

By comparing the writer's observations with those of Butler and Kulkarni (1913) it may be seen that the fungus causing the blight of gabi in the Philippines shows remarkable similarity to *Phytophthora colocasiæ* Rac. which was described as attacking gabi in India, Java, and Formosa. The writer believes that the fungus in the Philippines is identical with *Phytophthora colocasiæ* Rac. which was first reported by Mendiola and Espino (1916) and subsequently by Reinking (1918).

## LIFE HISTORY OF PHYTOPHTHORA COLOCASIÆ IN RELATION TO THE PRODUCTION OF GABI BLIGHT

Where gabi grows throughout the year the disease is always present, although in a lesser degree during the dry season. The disease occurs severely on gabis under shade. During the dry season the disease is found on wild gabis growing along streams and in swampy places. The disease is not severe during the dry season, but it is destructive during the rainy season.

### *Production of spores*

Conidia were practically the only spores produced by the fungus under field conditions during the present experiments. As soon as the infected tissues begin to die, a downy covering on the lower surface of the leaves was observed. This consisted of conidia and conidiophores of *Phytophthora colocasiæ*. During the course of the present work it was found that the conidia spread the disease in the field during the gabi growing season.

### *Longevity of spores*

Conidia of *Phytophthora colocasiæ* on leaves kept inside and outside the laboratory were viable for more than three months after they were gathered

from the field. The spores of the specimens kept inside did not germinate 15 days earlier than the spores of the specimens kept outside, although the conidia were still in good condition at the close of the experiment.

The specimens kept outside retained more viable spores for a longer period than those which were kept inside the laboratory. The above results show that the conidia are not capable of living on dead gabi tissues for more than three months. It seems probable that rotation of crop would help to reduce infection in the field.

*Spore dissemination*

*Phytophthora colocasiæ* is disseminated principally by means of conidia. During the course of the present work experiments showed that conidia may be splashed or washed by rain from leaves of infected gabis to leaves of healthy plants.

It was also noted in experiments that caterpillars of *Hyppotion celerio*[3] may transfer the conidia from infected to healthy gabi plants when they feed on them.

Other possible methods of dissemination of spores were not tested.

*Mode of infection and period of incubation*

When spores of *Phytophthora colocasiæ* come in contact with gabi leaves they germinate on the film of moisture or dew. The germ tubes produced, penetrate the host tissue either through the epidermis, through injuries, or through the stomata.

The period of incubation varies with environmental conditions. Under field conditions infection takes place in three to seven days. Under damp chamber conditions infection appears 36 to 48 hours after inoculation.

*Source of inoculum for natural infection*

Gabi planters harvest their crops after the plants are entirely defoliated. Sometimes the defoliation of the plants is taken as an indication that the crop is mature, although in many cases, especially during the rainy season, the defoliation of the plant is hastened by attacks of *Phytophthora colocasiæ*.

In the present experiments it was found that infected leaves and corms left in the field after harvest may form sources of inoculum for natural infection. Since the conidia are not able to remain alive for more than three months on leaves and petioles of gabis which are left on the surface of the soil, oöspores are probably formed on the more fleshy tissues of the gabi late in the season and these tide the fungus over to the next rainy season. The mycelium of the fungus in the more fleshy tissues of the gabi, such as the corms and petioles, if covered with a thin layer of soil is protected from drying. This mycelium probably grows during the early part of the rainy season and produces abundant conidia for dissemination. No work to ascertain the exact sources of inoculum in the field and how the fungus remains alive from one season to another was done during the course of the present study. Under field conditions in the Philippines the fungus grows on wild gabis along creeks and in swamps during the whole year.

[3] The writer wishes to thank the Department of Entomology for the determination of the caterpillars.

### ENVIRONMENT IN RELATION TO THE PRODUCTION OF DISEASE

The rains at the beginning of the rainy season hasten the rapid development of gabi leaves. On cloudy days the humidity of the atmosphere is relatively high. On warm moist days the condition of the atmosphere resembles that in the damp chamber. These conditions are favorable for the rapid development of the fungus on the host tissue.

The writer noted that the disease is severe a week after a continuous rain, owing, perhaps, to the spores splashed by the rain from infected to healthy leaves. In the field it was noted that infection was severe during a few rainy days in August, 1924, and also after continuous rain in October, 1924.

### CONTROL MEASURES

#### *Disease resistance*

Of the nine varieties of gabis tested, eight appeared to have practically the same degree of susceptibility to the disease. Variety Nagcarlang was the most susceptible.

In the present study the writer found no variety of gabi resistant to the disease. In raising gabis for commercial purposes in localities where the disease would be a limiting factor, yautia may be used. Substitution should be made if yautia meets the requirements of the consumer. Yautia is a heavy yielder and is not attacked by the blight of gabi.

#### *Sanitary measures*

In the field the collection and removal and destruction of diseased leaves either by burning or by burying them deeply, will help to reduce the sources of inoculum for primary and secondary infections.

The severity of attack of *Phytophthora colocasiæ* on the gabi plants in the field is influenced by the humidity of the air, hence close plantings and the planting of gabi in shady fields should be avoided. By planting the gabis farther apart the chances of transferring the spores by droplets of water are reduced and the free circulation of the air between the plants makes the air about the plants relatively dry.

#### *Crop rotation*

Crop rotation may be effective in the control of the blight of gabi. In the present experiment, however, no work was done to find out how long the fungus can remain alive as a saprophyte in the soil.

#### *Spraying*

The use of fungicides is an effective method of protecting gabis from infection of *Phytophthora colocasiæ*. During the course of the present study, spraying experiments were conducted in the field using commercial lime sulphur, Bordeaux mixture, one per cent formalin solution, and 10 per cent copper sulfate solution. Bordeaux mixture and commercial lime sulphur were prepared according to Reinking's (1918) formula.

Each of the gabi fields was divided into six lots. Each lot contained 80 plants. Each lot was sprayed with one kind of solution. Two lots were used as control. The control was carried in two ways. The infected plants on control I were counted and the infected leaves removed every two weeks.

Control II was left alone except that the infected plants were counted and recorded every two weeks.

Before spraying, the infected plants were counted and recorded and the infected leaves removed.

The experiment was started on August 31, 1924, and continued until November 11, 1924. The spraying was done with a hand sprayer at intervals of two weeks.

In this preliminary spraying experiment it was found that Bordeaux mixture gave the best results. Copper sulfate was second, but the concentration used (10 per cent) scorched the leaves. A lower concentration of copper sulfate did not show any effect in reducing the severity of infection.

One per cent formalin solution and commercial lime sulphur gave practically no effect over control I.

In mild cases of infection the removing and destroying of the infected leaves seems very effective in controlling the disease, as shown in control I. Bordeaux mixture gave the best results for checking severe attacks of the disease in the field. In severe cases of leaf blight of gabi in large commercial plantings spraying may be resorted to. The method of planting and cost of materials and labor should determine as to whether this method of control is more economical than proper sanitary measures and good cultural practice.

## SUMMARY

1. The leaf blight of gabi occurs on wild and cultivated varieties of gabis around Los Baños, Laguna, and perhaps elsewhere in the Philippine Islands. The disease has been reported in Java, India, Japan, and China.

2. Morphological and physiological studies show that the fungus causing the leaf blight of gabi in the Philippines is identical with *Phytophthora colocasiæ* which was first described in Java by Raciborski.

3. Potato-dextrose and potato agar are the best media for the cultivation of the fungus. Lima bean juice agar is best for the production of oöspores. Upo, eggplant, and papaya fruit cylinders are the three best substrata for the cultivation of the fungus.

4. The conidia germinate either by sending out germ tubes, or by the production of zoöspores. The zoöspores move about for some time after they are liberated, come to rest, and germinate by sending out germ tubes.

5. None of the varieties of *Colocasia antiquorum* used in the experiments were resistant to the disease. Other aroids and species of plants of other families are resistant to the disease.

6. Spores are disseminated by insects and water and probably by some mechanical means.

7. Infection takes on either surface of the leaves, and penetration is either through the epidermis, through injuries, or through the stomata.

8. Infected leaves and corms which are left in the field after harvest form sources of inoculum for natural infection.

9. The fungus probably tides over adverse conditions by producing oöspores. These oöspores may remain either in the soil with decaying gabi parts or within the corms.

10. The humidity of the air influences the severity of infection.

11. Proper cultural practice, sanitation, and spraying with Bordeaux mixture in severe cases will help to reduce the loss in gabi production. Yautia may be used in place of gabi in cases of serious infections in a locality, provided that the consumer will accept the substitution.

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## ILLUSTRATIONS

PLATE I

Fig. 1. A leaf of *Colocasia antiquorum* showing the early stage of infection of the gabi blight caused by *Phytophthora colocasiæ* Rac. (Photograph by the Bureau of Science, Manila, P. I.)

Fig. 2. A leaf showing the advanced stage of infection of *Phytophthora colocasiæ* Rac. (Photograph by the Bureau of Science, Manila, P. I.)

PLATE I

# DUCK-LIKE POSTURE AMONG HENS[1]

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WITH ONE TEXT FIGURE

"Duck-like posture" is a symptom sometimes associated with certain afflictions of the egg-producing organs of hens. This symptom is so named because of the nearly upright posture that the affected hen assumes, much like that of a Runner Duck. The duck-like posture has been observed frequently in hens with misplaced eggs or egg materials in the abdominal cavity (Johnson, 1924); also in extreme cases of egg bound, that is, where eggs are retained unnecessarily long in the oviduct (Bushnell and Hinshaw, 1924). A case where a bird has assumed a duck-like posture was noticed on December 20, 1924, in one of the Single Comb White Leghorn hens of the College flock.

Some time in 1923, the writer's attention was called to a hen which had "mysteriously" assumed the duck-like posture. The owner thought that the condition of the bird was so unusual that he placed it among the garden day exhibits of the town that year. Later, the "mysterious looking hen", as the owner called her, was opened and, true to expectation, five normal sized yolks were found encapsulated on the floor of the abdominal cavity of the bird. This hen had been a fairly good layer, but because of some disturbances the funnel or the infundibulum of the oviduct failed to catch the yolks and five fell uninjured into the abdominal cavity. This weight probably was enough to cause the hen to assume the peculiar position, known as duck-like posture.

In some cases, the bird may continue to abort her yolks in the abdominal cavity without any apparent harm. In most of the instances observed in the College, however, the aborted yolk into the abdominal cavity ruptured, the material was partially absorbed, and the unabsorbed portion decomposed and death followed as a result of autointoxication (Fronda, 1923). Ward and Gallagher (1920) report that "quite frequently as many as five to seven perfectly formed yolks in a good state of preservation are found between the intestinal convolutions" of hens. Such cases, however, are rare and in most of them the birds so affected have inflammation in the abdominal cavity and sudden death follows without their previously showing the "duck-like posture" or any other symptom.

A rather uncommon case of this nature was observed in a White Cantonese hen, A 24, of the College flock. The hen had been laying fairly regularly up to about two weeks before she was found dead in the nest. On October 12, 1924, this hen laid an egg, but she skipped on the 13th and 14th, and in afternoon of October 15, she was found dead in the nest. Some time in the morning of that day, the bird was seen to be limping and standing in a rather upright position, with the abdomen unusually distended. As she died that afternoon no further observation was made on the living bird. On post-mortem examination, two

[1] Experiment Station contribution No. 327. Received for publication, September 17, 1925.

normal sized eggs, one with a normal shell and the other with a soft shell, were found lodged in the abdominal cavity of the bird. Another normal sized egg, apparently complete in every respect and ready to be laid, blocked the oviduct almost at the entrance into the rectum. The other internal organs were apparently normal, and the bird was in an excellent laying condition before she died. Probably, death was caused by over-exhaustion.

Fig. 1. Single Comb White Leghorn hen, A 50. Photograph was taken on December 23, 1924, when the bird's position was duck-like. Except for this, there was apparently nothing wrong with the bird.

Still another very interesting case in the College flock which attracted some attention was that of Single Comb White Leghorn hen, A 50, that died of fowl cholera on May 23, 1925, while under observation. The bird was first noticed to have assumed a duck-like posture on December 20, 1924, and on December 23 she was photographed (fig. 1). This bird was one of the best layers in the College flocks, and even after she was so afflicted that she could hardly get up into the nest, she managed to lay fairly regularly. The bird was carefully observed from December 20. On January 1, 1925, she was noticed to be almost normal in position and apparently normally active. She again began laying on January 8, stopping on February 12, after laying her seventeenth egg in that particular batch. The bird at times would be seen dragging her tail, especially on leaving the nest after laying, but most of the time she posed normally. She did not assume the duck-like posture except when she was laying actively. There were times when she was apparently normal in every respect before going inside the nest to lay, but after laying she could hardly walk.

The bird from December 20, 1924, to the time of her death, May 23, 1925, did not markedly change in appearance. At four different times during this period she was closely examined to see what the trouble was. At first it was suspected that either an egg might be misplaced in the abdominal cavity, or that there might be some dropsical swelling in the abdomen. On examination, every part of the bird appeared normal, and there seemed to be no foreign body in the abdominal cavity. The forefinger was inserted at different times into the oviduct

and into the rectum but failed to reveal anything radically wrong except the presence of a somewhat soft body on the floor of the abdominal cavity. This soft body was considered unimportant and was passed over. The bird was laying large, normal, white-shelled eggs, and was the pride of the Single Comb White Leghorns having been at top of the list of our ten best layers prior to the time she assumed the duck-like posture.

On May 23, 1925, the bird died suddenly. Post-mortem examination showed typical symptoms of fowl cholera. This particular pen had been suffering from a mild attack of this disease for some time. The heart showed the typical hemorrhages and red spots, and the liver was enlarged and friable and covered with numerous small necrotic grayish spots. There was a small amount of clear liquid in the abdominal cavity and in the sac surrounding the heart. The walls of the intestines were slightly hemorrhagic. All the rest of the internal organs were apparently normal. There was a very interesting abnormality in the nature of a bag with transparent walls which was filled with clear liquid. The bag was about 5.5 centimeters in diameter and was provided with a rather long peduncle. It was lying close to the cloacal opening into the rectum. The structure looked like a large yolk ready to drop from its sac and was provided with a thick net-work of blood vessels on the surface. Perhaps this was nothing more than an ordinary retention cyst with the long stem attached somewhere in the ovaries. This particular cyst was probably the sole cause of the hen's trouble previous to the attack of cholera. The weight of the cyst added to that of the large egg that the hen was producing was probably sufficient to cause the bird to assume a duck-like posture. There may have been other troubles, but, if so, the writer is unable to tell what.

Although cases of duck-like posture may be rare, it pays to be ready for any that may arise. The first step to be taken is to look for the cause of the trouble. If it is misplaced egg material, the trouble may not be noticed at all until the odor of decomposition can be detected when it is usually too late to attempt any remedy.

If the trouble is caused by misplaced eggs, the bird may be relieved by opening the abdominal cavity and removing such eggs. However, as the tendency is for the fowl to again have the same trouble, there is the question whether the operation will pay or not. If the trouble is caused by the presence of a cyst similar to the case just described or if it is due to a collection of fluid in the abdominal cavity (dropsy), an operation will probably be all that is necessary. An operation was not attempted in the case of the White Leghorn hen here described, because the bird was a valuable one, and it was the plan to get as many of her eggs as possible and have them hatched during the most favorable months of the year before operating upon her.

Extreme cases of egg bound may also cause the bird to assume this position. If egg bound is caused by either inflamed, twisted, or stricted oviduct, treatment is not practicable. Egg bound, however, is more common among pullets that are just beginning to lay where the egg may be either too large or the oviduct may not have been sufficiently dilated for the purpose. Mature hens may become egg bound also by attempting to lay extremely large eggs or eggs that are malformed. The affected bird in both cases, in addition to being restless and

frequently visiting the nests and attempting to lay, may assume a duck-like posture. Treatment in such cases is comparatively simple.

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## EXCHANGE NOTES

The raisin growers of America report having discovered a new use for raisins. They are found to be effective as an afternoon bracer to take away "that sleepy feeling". It is reported that a number of large business corporations are now serving a small package to their entire office force as a mid-afternoon bracer. One of the best known newspaper offices in Canada has arranged for small packages of raisins to be passed among their employees each afternoon, and every employee, from the printer's devil to the president, takes ten minutes to refresh themselves with a handful of appetizing and healthful raisins. The practice might well be adopted here.

FEDERAL DEPARTMENT OF MARKETS AND MIGRATIONS, MELBOURNE.
Reprinted from *The Agricultural Gazette*, (New South Wales).

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The fundamental problem of farming is the problem of selection—of eliminating the forms of plant and animal life which we do not want and preserving and multiplying those forms which are useful to us.

*The Prairie Farmer.*

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A few years ago (says the "Louisiana Planter") the manufacture of building boards out of bagasse was successfully and economically started in Louisiana. The progress of this industry has been favourable, resulting in a rapid expansion, which in the last few years has taken the entire output of bagasse from a number of factories in Louisiana, and enabled them to economically and successfully replace the bagasse by other fuels for the manufacture of sugar. Bagasse thus by this use is rapidly becoming a source of revenue to the cane sugar factory, and this industry promises in a short time an even more rapid extension than it has had in the past.

*The Australian Sugar Journal.*

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* * * * Unless Ceylon opens her eyes and produces articles of food herself, she is in danger of starvation.

It is over a century since Ceylon came under the British flag and there have been no wars and peace has prevailed uninterruptedly, yet the inhabitants do not appear to have made any effort to raise their own food grain and have even allowed the great part of the island to be overgrown with jungle or have their attention turned to commercial crops and coconut plantations. The progeny of planters invariably hunt after luxury and their sphere of usefulness is very limited to their country and people. It is high time that serious consideration is given to this problem.

*The Journal of the Madras Agricultural Students' Union.*

Some years ago rats began to manifest themselves in something approaching plague numbers in Hawaiian cane fields and, protected as they were by the forest of cane stems, they multiplied rapidly and began to destroy considerable quantities of the cane itself and certain fruits. With the failure of the mongoose, mechanical means of control have had to be resorted to on a large scale, while poison is often freely used. A method advocated is the use of barium carbonate baits, the procedure being first to set unpoisoned wheat (in five places to the acre) for a period of about two weeks until every rat and mouse knows where it is, and then to substitute the poisoned baits. This is done three times a year with such success that the 1924 crop of cane harvested at Honokaa (an important plantation) showed practically no rat-bitten cane and the plantation got fully sixty thousand dollars worth of sugar which had hitherto gone to feed the rats. The total cost of the work here has been about five thousand dollars annually.

*The Journal of the Madras Agricultural Students' Union.*

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Studies of control work by S. B. Freeborn with roundworms of poultry showed nicotine to be the most satisfactory drug for eliminating these worms. "Tobacco dust which contains from 1.5 to two per cent nicotine fed as two per cent of the dry mash daily for three or four weeks removes approximately 100 per cent of the large intestinal worms (*Ascaridia galli* Schr.) and 85 per cent of the cecum worms (*Heterakis gallinae* Gme.).

*California Cultivator.*

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In a few seconds Nature can destroy man's work of years. But the destruction is not permanent. Slowly and painstakingly he rebuilds, and in time the scars of flood or tornado are healed. The resources of Nature are infinite, and the man who would grow from the soil the things he wants, and those only, must wage constant war against weeds and bugs and germs.

*The Prairie Farmer.*

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Hawaii is planning a survey to determine what new industries might be developed in the islands. Up to the present the country's industrial efforts have been largely concentrated on the production of sugar and pineapples. Sugar alone normally makes up from 60 to 70 per cent of the total exports, while sugar and pineapples taken together account for 90 to 95 per cent of shipments from the islands. The welfare of the community therefore depends almost entirely upon these two crops. Either a crop failure or a slump in the world market price of sugar or pineapples affects adversely the entire community. Establishment of additional industries such as are suitable for the islands, and the diversification of agriculture, should do much to add to the stability of the islands' prosperity.

*Commerce Reports* (U. S. Department of Commerce).

## COLLEGE AND ALUMNI NOTES

Dean Baker, Doctor Roxas, Doctor Pendleton, and Doctor Mendiola were among the speakers from the College at the convention of the Philippine Sugar Growers Association in Manila the first week of October.

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Dr. Sidney C. Harland, professor of botany and genetics at the Imperial College of Tropical Agriculture at Trinidad, B. W. I., visited the College on October 2. Doctor Harland had warm words of praise for the work done by the College faculty and expressed himself as most favorably impressed with the suitability of the location and equipment for a real College of Tropical Agriculture.

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Mr. McClure, professor of botany in Canton Christian College, China, spent several days on the Campus in October. He was particularly interested in collecting bamboos for shipment to the Canton College.

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The last number of *The Makiling Echo*, a quarterly published by the Forest School, presents several articles of value and interest. Among these are: "Rubber in the Philippines" by A. H. Muzzal; "An Efficient Method of Germinating Lumbang" by Ranger Evarieto Tabat; "Wanted: Forest Experiment Stations" by Forester Antonio P. Racelis.

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The staff of the English Department went to Batangas on October 12 for the purpose of visiting the provincial high school. As our students for the most part come from the high schools and the seventh grade, some personal knowledge of the methods followed in these schools aids the English instructors in bridging the break between these institutions and our College. The staff report that the day was profitably spent.

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On September 17, in Manila, Miss Hazel Kenward and Forester Otto W. Pflueger of the Forest School were married. Mrs. Pflueger was formerly assistant professor of chemistry in the College of Agriculture. Mr. and Mrs. Pflueger will live on Faculty Hill in one of the Forest School cottages.

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Under the colorful and suggestive title of *The Green and Gold* a student publication has made its appearance on the College Campus. The green of life and spring and the gold of harvest and fulfillment are the symbolic colors of agriculture. The nature and purpose of this literary fledgling is to reflect and record the student life and activities in the various departments, social and scholastic, of the College and to encourage student self-expression.

Mr. Basilio Hernadez heads the staff as Editor-in-chief, with Miss Mamerta Manahan as Business Manager, and Miss Victoria Mendiola, Assistant Business Manager. The Associate Editors are:

(Miss) Mamerta Manahan.....Women's and Literary Sections
Silverio Cendaña.....School Calendar and Campus News
Hermenigildo Rosales.....Social News
Dionicio Calvo.....Sports
Cornelio del Rosario.....Art and Jokes
Assistant Professor Llenado.....Spanish Section

Miss Margaret Wilson of the English Department is Faculty Adviser.

Society organizations, class and department reporters make up the editorial staff.

The number of student contributions in the first two biweekly issues promise a keen interest and support to the College *The Green and Gold.*

Subscription: One Peso a year.

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The heavy rains during the week preceding Loyalty Day, October 10, curtailed the Parade Ground and Athletic Field programs. The weather, however, did not interfere in any way with the evening celebration. The program given in the Auditorium follows:

Music—by the College Orchestra
Reminiscences of a National Guard veteran—by E. G. Collado
Violin Solo—by F. Ortaliz
One Act drama—"The Radiant Symbol"

Cast of Characters

Don José.....A. Muyargas
Andong.....P. Ungos
Toñing.....M. Arnaldo
Rosita.....V. Mendiola
Chief of Police.....F. Polutan
Servant.....C. Villanueva

Vocal Solo, "Torna"—*L. Denza*
By Miss M. Manahan
Mr. Ibanez at the piano
Address—Dean C. F. Baker
Award of Athletic medals and ribbons by Dean Baker
"Poema de dolor y juramento de lealtad a Filipinas"—*Agustin Llenado*
Read by Hermenigildo Rosales
Selection by College Orchestra
One Act Drama—"Puring's Choice"

Cast of Characters

Don José.....C. R. del Rosario
Puring.....Purificación Caguicla
Julian.....José Barsana
Rosita.....Mamerta Manahan
Honorio.....E. Almazan

"Philippines, my Philippines" and "America"—Audience

A letter containing much of general interest was recently received by Doctor Mendiola from Mr. Teodorico P. Reyes, M.S. '25. The letter was written under the heading, "California Packing Corporation, Wahiawa, Oahu, T. H." An extract follows:

* * * * . It might interest you to know that "Del Monte" canned products—fruits, vegetables, and fish—are prepared by this company in its canneries in California and other parts of the Pacific Coast. Its Hawaiian interests deal solely with the growing and canning of the pineapple.

In and around Wahiawa, where I am at present located, is a veritable sea of pineapples; even the lower hillslopes and the gulches are dotted with blocks and blocks of this crop. The plantations belong to three or four canneries, with the Hawaiian Pineapple Company, the pioneers in the pineapple industry, having the lion share. In some instances the fields of the different companies lie side by side, so that differences in the plants or crops as a result of different fertilizer and spraying treatments are often very apparent. All the plantations employ the mulching paper, apply rather extensively their own fertilizer mixtures, and spray their plants with ferrous sulfate solution every once in a while. I might add that one of the brands of mulching paper employed here is a "certain-teed" product, quite similar to the certain-teed roofing material so widely advertized as such in the Philippines. The usefulness of the mulching in pineapple fields is evidently beyond question; hence, its universal employment.

I am with the experiment station section of the C. P. C. We conduct many and varied experiments in our own pineapple fields from fertilizer experiments to plant breeding studies. In our rounds and rambles through the fields we occasionally find bud sports, freaks, and other unusual creations. For instance, I have seen exceedingly big-eyed fruits, striped fruits, and variegated plants. There is something in the last group which might interest you some, for it may throw light on the question of white-green variegation in the pineapple which I think you brought up in a paper of yours some time ago. The variegated plants or rather plantlets which I have seen here are crowns borne on fruits of normally green plants. There are two such white-green crowns and the suckers and slips in the same plants are of the usual color—green. And what makes these cases the more peculiarly interesting is that the fruits are also variegated; a narrow red band runs lengthwise on each fruit. A bit of correlation, is it not? It might be that the original variegated pineapple in the College appeared as a sporting crown, don't you think so? Still it might have been a slip or a sucker originally, for spiny (all over) slips or suckers or both are occasionally found among normally smooth slips and suckers.

That Hawaii has many varieties of Hibiscus, you of course know. Hibiscus is certainly one of the most popular ornamental plants in this little country. Why, it even plays the rôle that *Varleria cristata* has in many lawns and gardens in the Philippines—as a hedge plant. In the coming Territorial Fair, which will take place during August 31 to September 9, there is a subsection in the "Agriculture and Plant Life" exhibits to be devoted mainly to Hibiscus. I shall not attempt to enumerate or describe here the forms of gommamela that I have so far seen in this "Paradise of the Pacific," because I know you are familiar with practically all of them. In fact I tell some friends here that Los Baños will soon boast of more Hibiscus varieties than Hawaii. Maybe some of your Hibiscus seedlings are now in flower or have already flowered. * * * * *

Mr. Hilario Silayan B. Agr. '17, was a Campus visitor recently. For the past six years Mr. Silayan has been in California, part of the time employed on Doctor Copeland's rice farms and part of time studying in University of California. Mr. Silayan, on his return to the Philippines a few months ago, was employed in the Irrigation Division, Bureau of Public Works.

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*LIST OF BOOKS ADDED TO THE LIBRARY OF THE COLLEGE OF AGRICULTURE, SEPTEMBER, 1925*

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